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JOHNS HOPKINS
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DEPARTMENT OF GEOGRAPHY AND ENVIROMENTAL ENGINEERING

GEOMORPHIC RESPONSE TO A MEANDER CUTOFF:

SOUTH FORK SALMON RIVER, IDAHO

Final Report
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EXECUTIVE SUMMARY

A meander bend on the South Fork of the Salmon River (SFSR) was cut off during a large flood on June 17, 1974. In the 17 years since the oxbow breach, up to 2 m of sand and fine gravel have been deposited in the meander oxbow, and the breach has continued to downcut and has widened by 10 m. As a result of these channel changes, the proportion of river discharge captured by the breach has increased from less than half in 1974 to more than 80% today for most river discharges. The new river path through the breach shortens the river course by 700 m, producing a locally steep section through the breach. The response of a river channel to an abruptly steeper reach is generally one of erosion immediately upstream of the steep section and deposition immediately downstream, as the channel tends toward a smoother profile. Similar channel changes in the vicinity of the SFSR cutoff would have a negative impact on fish habitat. Erosion would threaten chinook and steelhead spawning gravels located upstream of the breach and downstream deposition could be detrimental to rearing habitat.

The goal of this study is to assess the impact of the meander cutoff on the local channel morphology and sediment budget, with a particular focus on channel erosion and deposition in the immediate vicinity of the cutoff. We use field observations, aerial photographs, historical observations, and hydraulic modeling to reconstruct the response of the channel to the cutoff.

In the 17 years since the cutoff, the breach has widened by more than 10 m and the bed of the breach has scoured by 0.50 m, producing a sediment load to the stream of 7,000 m^3. In the reach upstream of the breach, channel change has been relatively minor and is difficult to detect within the error of field estimates. No appreciable channel widening has occurred and the bed has remained essentially unchanged at the spawning gravels located 300 m upstream of the breach. Closer to the breach, a presumed coarsening of the bed sediment suggests that some bed scour may have taken place since the cutoff. A comparison of the present longitudinal channel profile with an estimated precutoff profile suggests the bed may have scoured 0.15 m to 0.20 m along a reach located 100 m to 200 m upstream of the breach. Since the cutoff, the oxbow has partially filled with up to 16,500 m^3 of sand and fine gravel. Downstream of the cutoff, aerial photographs

suggest that some bank erosion and slight channel widening have occurred. This widening may be driven by bed aggradation, the evidence for which is primarily an apparent increase in the area covered by depositional bars since the cutoff. A conjectural comparison of the present longitudinal channel profile with an estimated precutoff profile suggests the bed may have aggraded by as much as 0.6 m over a 300 m reach, resulting in deposition of up to 5,000 m^3 of material. Although the amount of deposition downstream of the breach is poorly known, it appears likely that some deposition has occurred.

The oxbow cutoff reach represents a net sediment sink to the SFSR during the 17 years following the breach. A new supply of 8,200 m^3 of sand and gravel eroded from the breach and upstream channel is more than balanced by deposition in the oxbow of 8,300 to 16,500 m^3. This has resulted in a net deficit of up to 8,300 m^3 to the downstream portion of the study reach. This reach has undergone net deposition of up to 5,000 m^3, resulting in a net deficit of up to 13,300 m^3 of sediment for the entire study reach over the 17 year period following the breach. This figure represents roughly 10 percent of the sediment load that would have normally passed though the study reach during the flows that have occurred since the cutoff.

During the period of oxbow filling, one may expect that the oxbow reach would represent a net sediment sink to the river. The sediment that reaches the downstream section may also be coarser than the normal sediment load because the oxbow preferentially traps finer sediment and because the sediment eroded from the breach and upstream channel will produce sediment coarser than the normal load. The breach sediment is freshly eroded (although highly weathered) and is coarser in size than the normal river load. This coarser sediment may not have been transported any great distance by the flows that have occurred since the cutoff. Thus, the downstream portion of the study reach may experience both a net decrease in the quantity and an increase in the caliber of the sediment delivered to it since the cutoff. The coarser sediment load is considerably more difficult to transport and can, therefore, result in deposition downstream of the breach, even in the presence of a net decrease in sediment input to the reach. As the oxbow continues to fill, it will lose efficiency in trapping sand and gravel and the amount of sand and fine gravel delivered to the

downstream reach will increase. At the same time, it is likely that the rate of breach erosion will decrease with time, thereby decreasing the rate of supply of coarser grains from breach erosion. Because the oxbow represents the major sink of sediment in the study reach, the downstream section is likely to receive an increasing supply of an overall finer sediment load once the oxbow is nearly filled, which will produce continued deposition of increasingly finer material in the downstream section.

Channel changes observed since the cutoff must be considered in the context of the flood discharges of that period. The breach-forming flood, the largest on record, was 139 m^3/s. Although there have been many years with relatively small floods since the cutoff, four of the largest eight floods in the 24 year record available for the SFSR have occurred during this period. These floods have all exceeded 85 m^3/s, which was the precutoff bankfull discharge in the alluvial sections of the study reach and should, therefore, be capable of producing channel changes in response to the cutoff.

Analysis of channel hydraulics before the cutoff, immediately after the cutoff, and in 1990, suggests that the oxbow breach caused the bed shear stress acting on the channel bed upstream of the cutoff to increase for any given discharge. This results from the greater slope of the water surface as the flow passes through the short, steep breach section. This increased shear could produce the bed scour we postulate in the reach immediately upstream of the breach. During floods in excess of the precutoff bankfull discharge, the excess shear developed by the cutoff at a cross section 150 m upstream of the breach has decreased over the 17 year period following the breach. This result may be attributed to our postulated decrease in bed elevation (bed scour) along that reach over the postcutoff period. Nonetheless, the present bed shear at that section remains 60% greater than precutoff values for the precutoff bankfull discharge (85 m^3/s, return period of $\approx$3 years) and 25% greater than precutoff values for a 50 year flood discharge (142 m^3/s). At the location of the spawning gravels 60 m further upstream, the 1990 values of bed shear stress have continued to increase since the cutoff to levels of roughly 60% greater than that present in the precutoff channel. Again, this change in local bed shear over time is a direct consequence of

incorporating the postulated lowering of the channel bed downstream into our hydraulic modeling. Regardless of this temporal change, our hydraulic analysis of the present and precutoff conditions shows that, for a given discharge, the bed shear acting over the spawning gravels is more than 50% higher today than before the cutoff. This suggests that, despite the fact that these gravels have not undergone net erosion in the period since the cutoff, they may, nonetheless, be subject to scour during a large flood in the future.

Overall, the oxbow cutoff has produced relatively minor channel changes in the 17 years following the breach. This period has included four floods that we judge to have been capable of producing some channel response to the cutoff. Some deposition downstream of the breach has occurred (although the amount of deposition is difficult to quantify) and further deposition is likely as the oxbow continues to fill. Overall, the downstream changes may not represent a serious deterioration of the fish habitat, because the cutoff has created a large scour pool immediately below the breach that provides rearing habitat. Slight erosion has occurred upstream of the breach, although erosion has not extended to the location of the spawning gravels. However, we cannot conclude from this that the upstream gravels are not at risk of erosion; the hydraulic analysis clearly demonstrates that the bed shear stress and the potential for erosion has been increased by the breach. Since the cutoff, upstream scour has proceeded at a sufficiently slow pace that it is likely that, under a range of flows similar to that of the past 17 years (floods less than 110 cms, with a return period of 10 years or less), any future scour of the spawning gravels will be relatively slow and could be accompanied by replacement from upstream gravels. However, floods larger than those occurring since the cutoff (discharge greater than 110 cms and a 10 year return interval), will produce bed shear stresses over the spawning gravels that are as much as 50% higher than precutoff values and have the potential to erode the spawning gravels, transporting them through the breach and depositing them in the downstream reach.

1. INTRODUCTION

1.1 PURPOSE OF STUDY

A meander bend on the South Fork of the Salmon River (SFSR) was cut off during a large flood on June 17, 1974. The meander bend originally formed a 900 m diversion around a granitic ridge oriented transverse to the general downvalley direction. The breach through the ridge occurred at a location close to the river position both upstream and downstream of the ridge and shortened the river course by 700 m. The cutoff has had two clear effects on the local channel morphology. In the 17 years since the breach, up to 2 m of sand and fine gravel has been deposited in the meander oxbow and the breach has been downcut by 50 cm and widened by 10 m. As a result of these channel changes, the proportion of river discharge captured by the breach has increased from less than half in 1974 to more than 80% today for most river discharges. Because the path through the breach is shorter and, therefore, steeper than the path through the oxbow, deposition in the oxbow and erosion of the breach are likely to continue until the oxbow is entirely abandoned.

The response of a river channel to an abruptly steeper reach is generally one of erosion immediately upstream of the steep section and deposition immediately downstream, as the channel tends toward a smoother profile (Richards, 1982). Such adjustments are typical of meander cutoffs in broad alluvial floodplains (Shulits, 1955). Similar channel changes in the vicinity of the SFSR cutoff would have a negative impact on fish habitat. Erosion would threaten chinook and steelhead spawning gravels located upstream of the breach and downstream deposition could be detrimental to rearing habitat. However, it is difficult to estimate the fishery impact by drawing a simple analogy with alluvial channels, because the SFSR cutoff occurs in bedrock. Erosion and deposition in the cutoff vicinity are controlled largely by the rate of erosion of the breach itself, but the rates of bedrock erosion by fluvial processes are extremely difficult to estimate. In this study, we use field observations, aerial photographs, historical observations, and hydraulic modeling to reconstruct the channel response to the cutoff. The purpose of the study is to assess the impact of

the meander cutoff on the local channel morphology and sediment budget, with a particular focus on channel erosion and deposition in the immediate vicinity of the cutoff.

The report is organized into six chapters. Chapter 1 introduces the study, describes the study reach, and reviews previous research on the SFSR and on meander cutoffs. The methods and schedule of data collection are described in Chapter 2. In Chapter 3, we estimate the channel change that has occurred from the period immediately prior to the cutoff to the present day. Chapter 3 also includes an assessment of the impact of the cutoff on the sediment budget of the study reach. In Chapter 4, we describe the methodology and results of the hydraulic modeling performed to estimate the changes in hydraulic regime as the river channel adjusted to the cutoff. In Chapter 5, we use the results of the hydraulic modeling to describe the processes driving the channel change. This provides the basis for interpreting the channel change that has occurred to date and for estimating the range of possible future channel changes.

1.2 ACKNOWLEDGMENTS

This study was originally suggested by Walter Megahan of the U.S. Forest Service Intermountain Research Station in Boise, ID. The project was funded by Research Joint Venture Agreement No. INT-90520-RJVA between the U.S. Department of Agriculture, Forest Service, Intermountain Research Station and the Department of Geography and Environmental Engineering at The Johns Hopkins University.

We are grateful to Carolyn Bohn for helpful conversations, aerial photographs, surveying data, and logistical assistance. Conversations with Walter Megahan, Bert Kulesza, and Randy Zuniga helped us to reconstruct the history of the study reach since the cutoff. Brian McArdell and Jennifer Gilson provided assistance in the field. Danielle deClercq, Amir Erez, and Warren Teitz assisted with the sediment sieving.

1.3 DESCRIPTION OF THE STUDY REACH

The South Fork Salmon River is a major tributary of the Salmon River and drains an area of 3,290 km^2. The basin is characterized by the shallow highly erodible coarse-textured soils of the Idaho batholith. The channel is generally confined to a narrow valley with steep slopes. High

flows occur as a result of spring snowmelt and localized rain-on-snow and summer storms. Historically, the South Fork Salmon River supported one of Idaho's largest chinook salmon runs as well as a large run of steelhead trout (Megahan et al., 1980). Resident species on the SFSR also include rainbow and cutthroat trout, Dolly Varden, and mountain whitefish.

The cutoff is located 23 kilometers upstream of the confluence with the East Fork of the Salmon River. The reach of the channel selected for study extends 500 meters upstream and downstream of the breach and includes both the breach and the oxbow itself. The upstream boundary of the study reach was set to be several channel widths upstream of the spawning gravels located upstream of the breach. The downstream limit was chosen as the confluence of the South Fork with Camp Creek.

Although most of the SFSR is confined to a narrow steep-walled valley, the channel of the SFSR just upstream and downstream of the oxbow is relatively unconfined, flowing within a floodplain hundreds of meters wide. Several hundred meters of floodplain have formed on both sides of the channel upstream of the oxbow and breach. The oxbow itself is confined by steep slopes on both sides. The breach cuts through decomposed granitic bedrock which forms steep cliffs on both sides of the channel. A floodplain several hundred meters wide exists on the left side of the channel immediately downstream of the breach; a steep slope of the same bedrock ridge dissected by the breach forms the right side of the channel. Further downstream floodplain exists on both sides of the channel for about one half kilometer from the confluence with Camp Creek to the Miner's Peak bridge crossing. Just downstream of the bridge the channel is again confined by steep slopes on both sides.

Figure 1.3.1 is a map of the study reach with the existing dominant bed sediment identified. Upstream of the breach the bed is composed of gravel with a median size of 32 to 45 mm. The bed of the breach is mostly granitic bedrock with occasional deposits of boulders, cobbles, and gravel. The bed of the oxbow is mostly sand and fine gravel with occasional coarser material in the thalweg. Downstream of the breach the bed is composed of gravel similar to the upstream reach, however there is more sand in the bed.

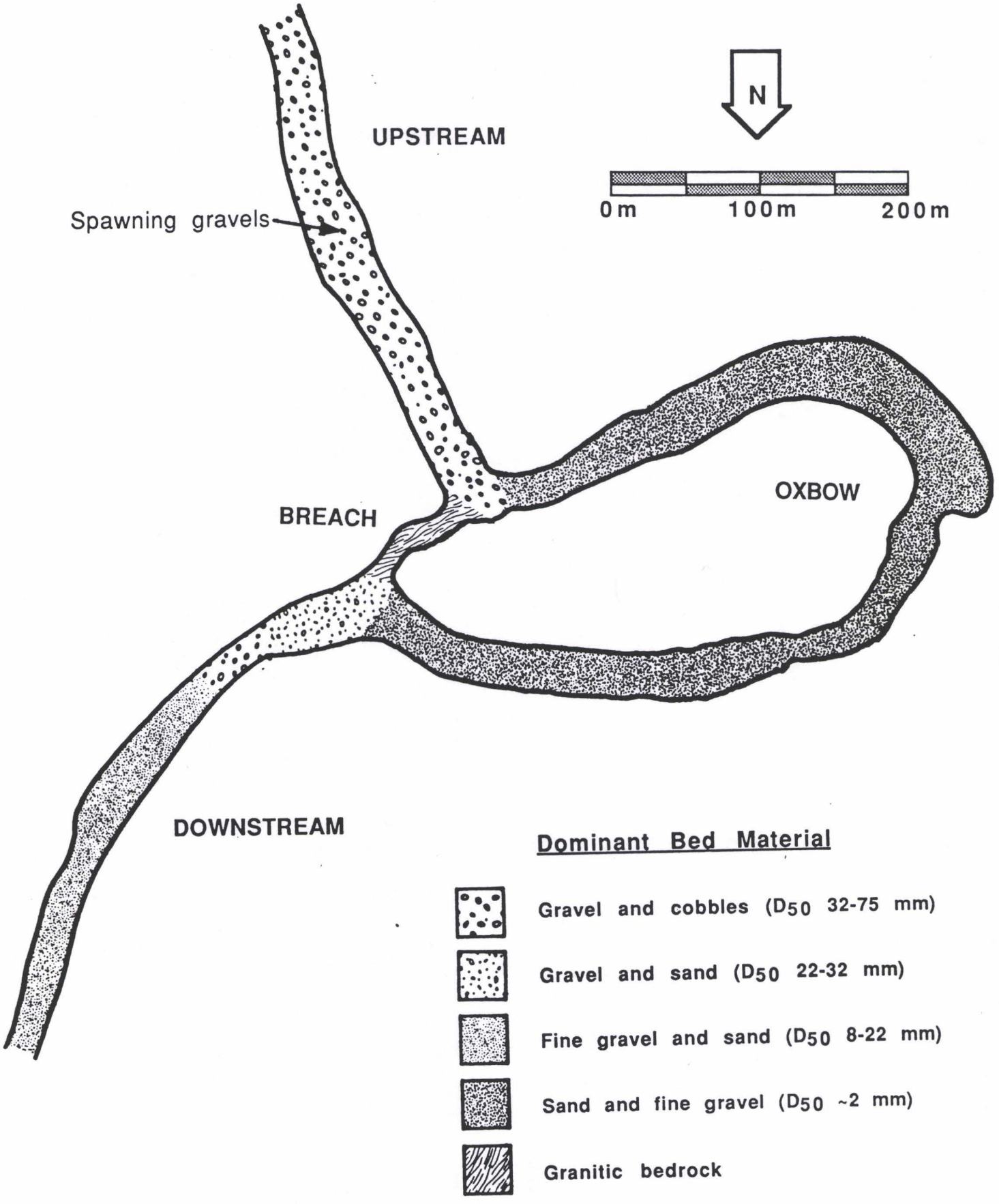


Figure 1.3.1 Study Reach Map

1.4 Literature Review

South Fork Salmon River

The SFSR has a remarkable history of sedimentation and recovery. Prior to 1940, mining and grazing in the basin were responsible for increased sediment and chemical loads to the channel and a degradation of riparian areas (Megahan et al., 1991). Logging and associated road construction occurred in the watershed between 1945 and 1965. Erosion as a result of this logging activity increased sediment input to the SFSR threefold (Megahan et al., 1991). This, combined with large storms in 1962, 1964, and 1965, caused extensive sand deposition in the channel which buried spawning and rearing areas, often to a depth of a meter or more (Megahan et al., 1991). In an effort to restore the degraded river habitat, the U.S. Forest Service declared a moratorium on all logging and road construction in the SFSR watershed in 1965 and began a restoration program. Since 1966, numerous watershed rehabilitation practices have been employed including the closing and stabilization of over 650 km of logging roads, revegetation, and stabilizing main access roads with improved drainage and retaining structures.

The watershed rehabilitation program and logging moratorium reduced sediment inputs from previously disturbed areas and prevented new disturbances. Megahan and others (1980) reported that statistically significant decreases in bed elevation and increases in bed particle size occurred in the main channel of the SFSR during the period 1966 to 1979. Once sediment inputs to the channel were controlled, natural flows of the SFSR were able to flush the previously aggraded sediments (mostly sand) from the bed. These changes resulted in a dramatic improvement in fish habitat and a limited reintroduction of timber harvesting with a comprehensive monitoring program begun in 1978.

Early monitoring showed no significant impacts from the land use changes and continued salmonid habitat improvement. However, beginning in 1981 an increase in fine sediments in spawning areas was measured (Platts et al., 1981). It cannot be shown conclusively that this increase in fine sediments was a direct result of logging rather than natural fluctuations (Megahan et al., 1991). However, because timber harvesting was contingent upon salmonid habitat

improvement, timber harvesting has not been permitted since 1984. Observations at the Stolle, Glory Hole, and Poverty Flats spawning areas showed increased levels of fine sediments from 1981 until 1987, followed by a decrease from 1988 through 1990 (Megahan et al., 1991).

In 1986, the Forest Service commissioned CH2M Hill to perform an engineering analysis to evaluate alternatives for stabilizing the channel in the vicinity of the breach. Five alternatives were considered, ranging from no action to closing the breach and dredging the oxbow. CH2M Hill (1987) concluded that restoring the channel to pre-breach conditions would involve the lowest cost, most benefits, and lowest risk of the alternatives considered. The CH2M Hill report also stated that if no action were taken, high velocities through the breach would cause continued erosion of the breach and of downstream banks. Their report further postulates that erosion of the upstream spawning gravels would occur if no action were taken although no evidence is presented of erosion of these gravels following the cutoff. Additionally, although, they noted that the scour hole downstream of the breach provides a good holding area for fish, CH2M Hill concluded that the overall effect of not restoring the channel to pre-breach conditions would be adverse to SFSR fisheries. Since the CH2M Hill study, spring snowmelt flows on the SFSR have been below average and no significant channel change has occurred in the study reach. This study provides a more detailed examination of the impact of the cutoff and the nature of future changes to the channel.

Geomorphic impact of cutoffs

Much of the work examining the geomorphic effect of meander cutoffs has focused on alluvial channels and artificial cutoffs designed to shorten rivers to facilitate navigation and limit flooding. Shulits (1936, 1955) presented a conceptual model for the evolution of the bed profile of an alluvial channel after a cutoff. Shulits' model is based upon the concept that alluvial rivers adjust themselves to an equilibrium slope or grade (Mackin, 1948). The adjustment to an equilibrium slope would occur by the upstream migration of a knickpoint and the deposition in the downstream reach . This deposition results from coarser sediment being delivered through the breach as a

result of the steeper upstream slope. The difficulty in applying such an analysis to the SFSR is that the channel in not strictly alluvial and its profile and planform are largely bedrock controlled.

Stream erosion of bedrock is conceptually simple; except where solution or flow cavitation occurs, the mechanism must be abrasion by entrained sediment (Shepherd and Schumm, 1974). Foley (1980a) developed a model of bedrock erosion in streams from engineering sandblast-abrasion theory. He found that uncertainties in estimates of bedload transport rates and particle kinematics yielded significant errors even for streams for which the strength of bedrock and sediment and hydraulics have been measured (Foley, 1980a & 1980b). At present, detailed modeling of bedrock erosion can provide, at best, only order of magnitude accuracy.

Deposition of sediment in cutoff meander bends has been described in detail by Shields and Abt (1989). Sedimentation occurs in two distinct phases, blockage and infilling. The blockage phase begins at the time of cutoff and terminates after one or both junctions to the main channel are blocked. Blockage occurs due to the deposition of bed-material load, usually in the form of bars within the first 25 percent of the cutoff bend or just upstream of its entrance to the main channel. Once the cutoff is blocked, flow is prevented from entering the cutoff bend except during floods (e.g. snowmelt on the SFSR). Infilling occurs via settling of suspended material from floodwater trapped by the bend. In contrast to the blockage phase, infilling usually occurs uniformly throughout the bend. Typical blockage phases last 2 to 10 years and the rate is controlled by the bedload supply, the ratio of cutoff length to bend length, and the angle of incidence between the cutoff and the old bendway (Gagliano and Howard, 1984). The infilling phase lasts until the oxbow shifts from a lacustrine environment to a terrestrial one.

2. DATA COLLECTION

2.1 FIELD OBSERVATIONS

Schedule

Three visits were made to the study reach. The first was a reconnaissance visit made by Alan Barta on August 23, 1990. An office visit included separate meetings with Carolyn Bohn and Walter Megahan of the U.S. Forest Service Intermountain Research Station in Boise, ID. A visit was made to the field site with Carolyn Bohn and the study reach was defined.

A second field visit was made between September 28, 1990 and October 8, 1990 by Alan Barta and a field assistant, Brian McArdell. After an initial meeting with Carolyn Bohn on September 28, we drove to the Krassel work center where housing had been arranged. The purpose of this visit was to survey the channel at low flow, when wading the channel was safe. Field work commenced the next day and included the following: (1) locating pre-existing cross sections, (2) monumenting new cross sections, (3) surveying of pre-existing and new cross sections, (4) surveying of longitudinal profile, (5) sediment sampling, and (6) mapping of the study reach. Upon completion of fieldwork, we met with Carolyn Bohn on October 8, 1990 to appraise her of the work completed. We also inquired about the existence of previous surveys of the pre-existing cross sections we found monumented in the field.

A third field visit was made between May 10 and 13 by Alan Barta and a field assistant, Jennifer Gilson. The purpose of this visit was to observe flow conditions during spring snowmelt. The following tasks were performed: (1) surveying of high water surface, (2) monumenting and surveying two additional cross sections in the oxbow, (3) measuring of the discharge in the oxbow, and (4) measuring depths of sand deposition in the oxbow.

A fourth visit was made in September 1991 to the Intermountain Research Station in Boise to locate old photographs and survey records by Alan Barta and Conor Shea. On this visit we also met with Carolyn Bohn and Jack King to discuss preliminary results.

Methods

Surveying

Twenty-five cross sections were surveyed using an automatic level and are shown on Figure 2.1.1. Six of these cross sections were above the breach (XS 1-6), nine were in the oxbow (XS 7,8,9,10,10.1,10.2, 11, 12, & 13), five were in the breach (XS 14-18), and five were downstream of the breach (XS 19-23). Forest Service monuments for pre-existing cross sections upstream of the breach and in the oxbow were located prior to surveying and reused. New cross sections were monumented with rebar and an adjacent wooden stake. No pre-existing cross sections were located in the breach or downstream of the breach.

Cross sections were surveyed by first setting a taut tape measure between the bank monuments. Level shots were made at intervals of less than one-half meter to three meters depending upon variation in topography; all breaks in slope were surveyed. The typical number of survey points for a cross-section was 30, although this ranged between a low of 19 and a high of 57 depending upon channel width and topography. In addition to cross-section surveys, the channel thalweg was surveyed at intermediate points if the cross sections were more than one channel width apart or if a dramatic drop in the bed or water surface occurred between the cross sections.

Characterizing the sediment

Sediment in the study reach was characterized to evaluate its mobility and to estimate roughness for the hydraulic modeling portion of this study. Visual estimates of bed material were recorded for each survey point of every cross-section. There were typically 15 to 35 channel bed survey points in a cross section, and the median size of the grains coarser than sand was recorded at each point. Additionally, pebble counts and bulk samples were taken at 20 locations. Pebble counts were done following the method of Wolman (1954). Bulk samples were of three types: 1) bottomless bucket, 2) grab sample in active channel, and 3) shovel samples. Bottomless bucket samples were made with a 20 liter (5 gallon) plastic bucket in which the bottom has been removed. This bucket is then worked into the bed and the sediment can be excavated. The advantage of this

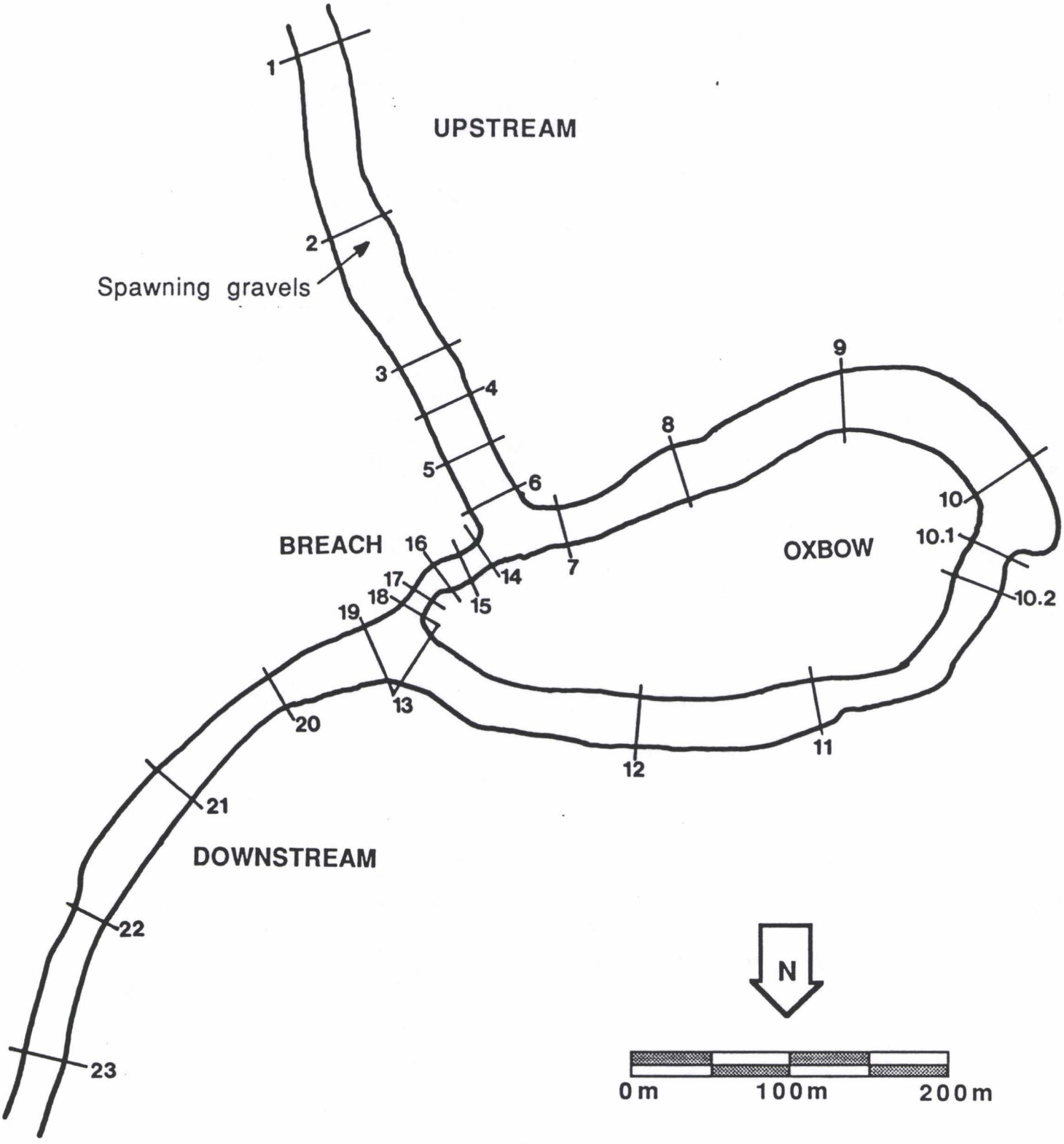


Figure 2.1.1 Cross Section Locations

method is that it allows sampling in shallow water without the bed filling in the sample pit. Grab samples of sediment were taken in water too deep to use a bottomless bucket. A 20 liter plastic bucket was used to scoop up sediment from the bed, usually at or near the channel thalweg. A shovel was used to take bulk samples of sediments deposited in the oxbow, because this area was not covered by water during low flow.

All sediment was sieved for size analysis in the sediment laboratory of the Johns Hopkins University. Grain size distribution data is included in Appendix B. Table 2.1.1 summarizes all sediment sampling performed and the median grain sizes at each sample.

Table 2.1.1 Sediment Samples and Median Grain Size

Location	Type of Sample	Median Grain Size (mm)
XS 2 Station 45 m	Bottomless bucket	54
XS 6 Station 32 m (in locally sandy location)	Bottomless bucket	16
XS 6 Stations 16-40m	Pebble	43
XS 7 Station 15 m	Bulk with shovel	1.3
XS 7 Stations 22-28m (thalweg)	Pebble	46
XS 8 Station 26m	Bulk with shovel	1.7
XS 9 Station 21m	Bulk with shovel	1.8
XS 9 Station 33m	Bulk with shovel	2.5
XS 11 Station 16m	Bulk with shovel	2.8
XS 13 Station 35 m 0-35 cm deep	Bulk with shovel	0.9
XS 13 Station 35 35-40 cm deep	Bulk with shovel	2.4
XS 19 Station 19 m	Grab sample with bucket	30
XS 19 Stations 24-37m	Pebble	41
XS 19 Station 37m	Bottomless bucket	30
XS 19 Stations 37-50m	Pebble	27
XS 21 Station 8.8m	Grab sample with bucket	18
XS 21 Station 23	Bottomless bucket	7.5
XS 22 2m radius about Station 18m	Pebble	16
XS 22 Station 18 m	Bottomless bucket	5.5

Sand Depth Survey

Measurements of sand depth in the oxbow were made to reconstruct the channel geometry for HEC-2 flow modeling and to estimate sand storage in the oxbow. Measurement were made by pounding a 10 mm diameter metal rod into the deposited sand in the oxbow until a very resistant

layer was reached. This resistant layer was interpreted to be channel bed gravels from the precutoff channel. A example of a reconstructed precutoff cross section in the oxbow is shown in Figure 2.1.2. In this report we refer to these reconstructed precutoff cross section as "desanded" cross sections. This method is similar to a method used by Carolyn Bohn with good results for measuring sand thickness in other reaches of the SFSR (Carolyn Bohn, personal communication).

Discharge Measurement

On May 10, 1991 the flow through the oxbow was measured using a pygmy current meter across cross-section 9. The purpose of this was to determine the proportion of flow passing through the oxbow and the breach. This provided a calibration for modeling the flow split between the two channels. Velocity measurements were made at 12 stations across the section following U.S. Geological Survey procedures (Buchanan and Somers, 1969). The computed discharge through the oxbow was 0.5 m^3/sec. The total discharge for the channel on May 10 was 18.95 cms (669 cfs), computed by scaling the gaged discharge at Krassel by relative drainage area.

2.2 AERIAL PHOTOGRAPH MEASUREMENTS

Because repeatable channel surveys were available for only one cross section prior to the cutoff, aerial photographs were used to determine channel widths and the extent of deposition and erosion. Aerial photographs from three dates were used: August 7, 1965; August 13, 1976; and June 6, 1989. Figures 2.2.1 a,b, and c are reproductions of portions of the photographs used.

Measurements on the aerial photographs were made using a 10 power magnifier with a 0.2mm recticle grid. There are four primary sources of error:

1) Estimating the scale of the photograph from landmarks,
2) Photographic distortion at different distances from the center of the image,
3) Locating the cross section on the stream, and
4) Defining the edge of the channel.

Figure 2.1.2 Typical Reconstructed Oxbow Precutoff Cross Section from Depth Probe Measurements of Sediment Thickness (XS 12)

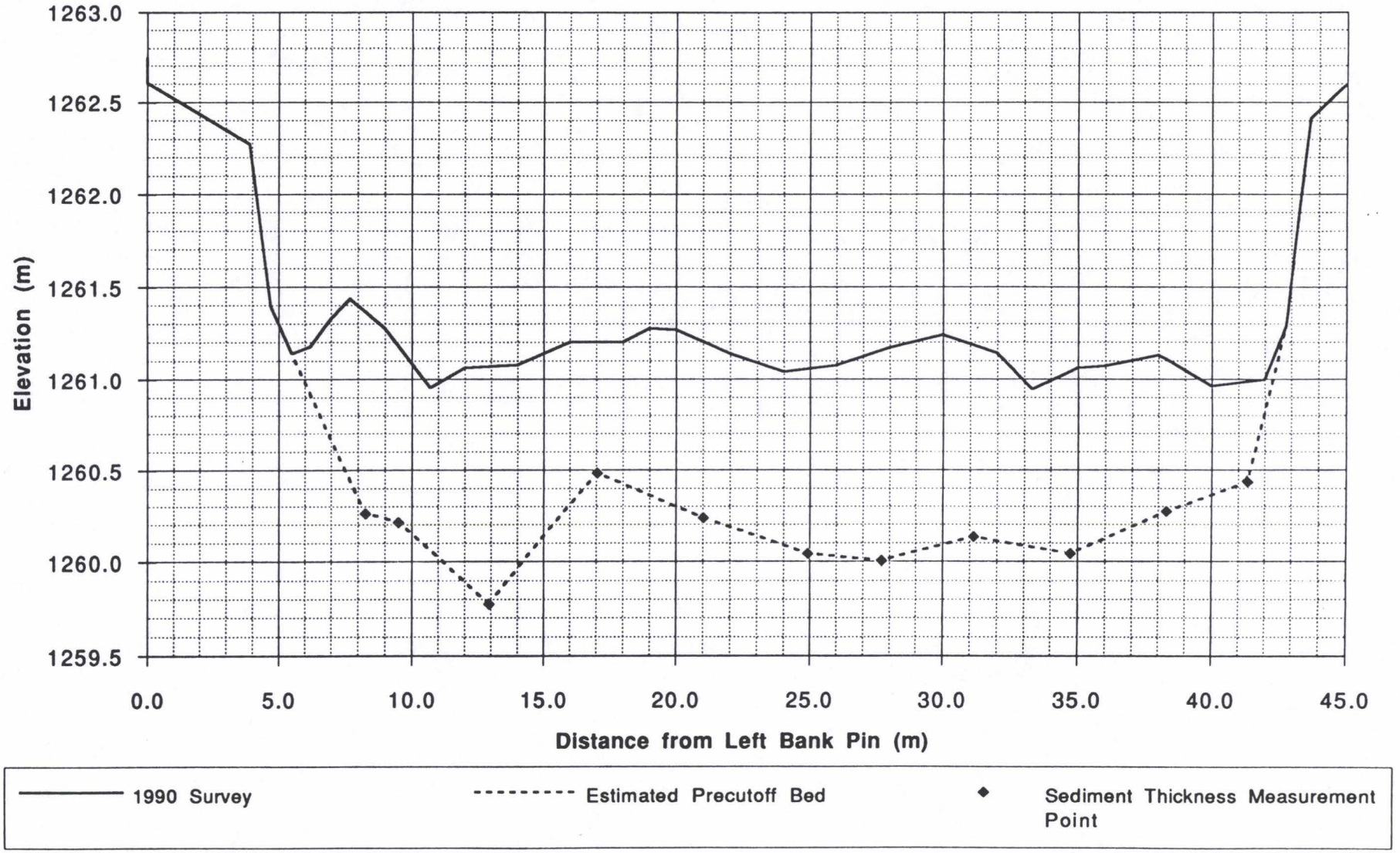


Figure 2.2.1a Aerial photograph of oxbow taken prior to the cutoff, August 7, 1965.

Figure 2.2.1b Aerial photograph of oxbow taken a short time after the cutoff, August 13, 1976.

Figure 2.2.1c Aerial photograph of oxbow taken June 6, 1989. Note the widening of the breach since the 1976 photograph (Fig. 2.2.1b).

Our procedure for measuring the photographs attempted to limit the magnitude of these errors. First we selected the photographs in which the study reach was located near the center of the photograph. Then, we calibrated our measurements by measuring between two sets of landmarks visible in all photographs and measured on the ground by us. We located the cross sections on the photographs using obvious landmarks and channel features (such as trees, rocks, etc.) to locate key cross sections. Other cross sections were located by measuring from these key cross sections. Identification of the channel edges was complicated by variation in river stage from photo to photo. To avoid this problem, channel width was measured from bank edges, rather than the edge of water.

Error bars were estimated by comparing the aerial photograph measurements from the 1990 photographs with surveyed cross section widths from 1990. Average error bars for our aerial photograph measurements of channel width are approximately ±2 m. These errors are slightly smaller (±1 m) for cross sections located near clear landmarks, with very well defined banks, in reaches without rapid downstream width changes, and without extreme shadows on the photographs. Error bars for cross sections difficult to locate with precision, with poorly defined banks, in regions with rapid downstream width changes, and with strong shadows on the photographs have slightly larger error bars (± 3 m).

2.3 HISTORICAL DATA, PHOTOGRAPHS, AND ACCOUNTS

In addition to aerial photographs, we used two other sources of historical data: cross section surveys and personal accounts and photographs. We have survey data dating back to as early as 1973 for a cross-section near the upstream end of our study reach (XS 2). Similarly, we have survey data dating back to the fall of 1974 (postcutoff) for a cross-section in the downstream portion of the oxbow (between XS 11 & 12). We were able to relocate the survey pins at cross section 2, but could only determine the general vicinity of the cross section between cross sections 11 and 12.

The most complete account we have of the cutoff is that of Bert Kulesza, the Forest Service hydrologist for the Payette National Forest at the time the cutoff occurred. He was part of a field

party that visited the site frequently after the cutoff. Kulesza remembers that flow continued uninterrupted through the breach after the cutoff occurred. This recollection is useful in constraining the elevation of the breach immediately after the cutoff. If the breach were above a certain height, the receding flow after the snowmelt peak would entirely flow through the oxbow and only flood flows would overtop the breach. Kulesza also noted that the breach did not capture all the flow, thus the discharge was split between the oxbow and the breach.

A photograph of a man standing in the breach taken September 16, 1974, was provided by Kulesza (Figure 2.3.1) and was used to estimate the discharge through the breach on that date. That discharge estimate and the total discharge from the USGS gage at Krassel are used in Chapter 4 to estimate the flow split between the oxbow and the breach on that date, and, therefore, the breach elevation.

Figure 2.3.1 Photograph of a man standing in the breach taken September 16, 1974. The discharge through the breach was estimated to be 1.84 cms (65 cfs) from this photograph and this was used to set the breach elevation immediately after the cutoff.(photo courtesy of Bert Kulesza).

3. CHANNEL CHANGES 1974-90

3.1 TIME FRAME

The cutoff on the SFSR occurred during the snowmelt period of 1974, probably on or near June 17, when the U.S. Geological Survey gaging station near the Krassel ranger station recorded a maximum discharge of 191 m^3/sec (6740 cfs). That discharge is the maximum in the 24 years of record for that station (since WY 1967) and, when scaled by drainage area, corresponds to a discharge of 139 m^3/sec (4900 cfs) at the oxbow reach.

We examined the morphology and hydraulics of the study reach for three particular time periods: (1) precutoff (1973), (2) immediate postcutoff (1974), and (3) present time (1990). We chose these time periods so that the channel changes affected by the 1974 breach-opening flood could be separated from postcutoff channel adjustments. The amount and quality of data for each period varies considerably.

Precutoff data available included the 1965 aerial photographs and one survey of one cross-section from 1973 (XS 2). *Immediate postcutoff* data included 1976 aerial photographs, oblique photographs of the breach taken by Bert Kulesza in the fall of 1974, and surveys of four cross sections upstream of the breach and one in the oxbow. The *present channel conditions* were ascertained from 1989 aerial photographs and our 1990 field survey. The availability of historical data and aerial photographs does not permit each time period to be as discrete as a day. Rather, each time represents a period of months to a few years in which the channel features are assumed to be stable relative to the changes observed from one period to the next.

The effects of the cutoff are distinctly different in different sections of the study reach. Therefore, the channel changes are most clearly presented in terms of four sub-reaches: (1) the breach, (2) upstream of the breach, (3) downstream of the breach, and (4) the oxbow. Each of these sub-reaches has experienced different erosional and depositional processes and will be described in its own section following a discussion of the general changes in the longitudinal profile of the entire study reach.

3.2 LONGITUDINAL PROFILES

The effect of a meander cutoff is to shorten the river and produce a local abruptly steeper reach through the breach. Because the effect of a meander cutoff is most clearly evident in the longitudinal profile of the river, we begin this chapter with a summary of the existing profile and our reconstruction of it before the cutoff.

We have plotted the longitudinal profiles using the average bed elevation at each cross section. Average bed elevation was computed using a weighted average of the channel bed only (excluding the bank and floodplain portion of the cross-section). This method minimizes bias due to the selection and spacing of survey points. For clarity, plots of the longitudinal profile around the oxbow and through the breach are plotted separately as Figures 3.2.1 and 3.2.2.

Figure 3.2.1 is the longitudinal profile through the oxbow. For the entire profile, average bed elevation is computed from our 1990 field survey. In the oxbow, also plotted on Figure 3.2.1, we have plotted our estimate of the precutoff bed. We calculated this elevation by subtracting our estimate of deposition since the cutoff from the average 1990 bed elevation. We refer to these reconstructed cross sections as "desanded". More detail on this technique and on the results is given in sections 2.1 and 3.5.

A line to estimate bed slope through the reach for precutoff conditions has been plotted on Figure 3.2.1. The line was fitted by linear regression through cross sections 1, 2, and 3 upstream of the breach, and the "desanded" oxbow cross sections (7, 8, 9, 10, 10.1, 10.2, 11, 12, and 13). Cross sections 4, 5, and 6 were excluded because downcutting may have occurred since the cutoff at these locations. Cross sections downstream of the breach were excluded because this may be an area of deposition. The slope of the regression line is 0.16 percent, which provides an estimate of the average bed slope through the study reach prior to the cutoff.

Overall, the slope through the study reach appears fairly linear. The rise in bed elevation at cross section 10.1 and upstream is due to a debris fan deposited from a side channel into the oxbow. The elevation at cross section 20 is located on the estimated precutoff bed even though it was not used in the regression analysis. Cross section 20 is the narrowest cross section

downstream of the breach and its present width is unchanged from its precutoff width. This narrow width constricts the flow producing high velocities preventing deposition from occurring. Deviations from the mean bed profile on Figure 3.2.1 at cross sections 4 through 6 and 19 through 23 are used in later sections to infer erosion and deposition in the study reach.

Figure 3.2.2 is a plot of the average bed elevation through the breach. Our same estimated precutoff slope is included although it has been shifted upstream to account for the 731 m channel shortening due to the breach. The break in the plotted precutoff mean bed profile clearly demonstrates the effect of a bend cutoff on a river's flow and transport. The breach is significantly steeper than the upstream and downstream reaches with a slope of nearly 2 percent. It is the tendency of rivers to 'smooth out' such short, abruptly steeper reaches that leads to erosion upstream of the breach and deposition downstream. A large scour hole is present at cross section 18. Immediately downstream of the scour hole is a large gravel bar on the right side of the channel. This gravel bar has deposited since the cutoff and accounts for the high bed elevation at cross section 19.

As the breach has gradually enlarged and captured more and more of the river discharge, the SFSR has gradually shifted from following both profiles in Figures 3.2.1 and 3.2.2 to following the breach profile almost exclusively. Immediately following the cutoff, 50 to 75 percent of discharges less than 80 cms, which include most of the discharges experienced in a normal year, passed through the breach. Today, more than 90 percent of such discharges pass through the breach (see Figure 4.6.1).

Figure 3.2.1 SFSR Longitudinal Profile of Average Bed Elevation Through Oxbow

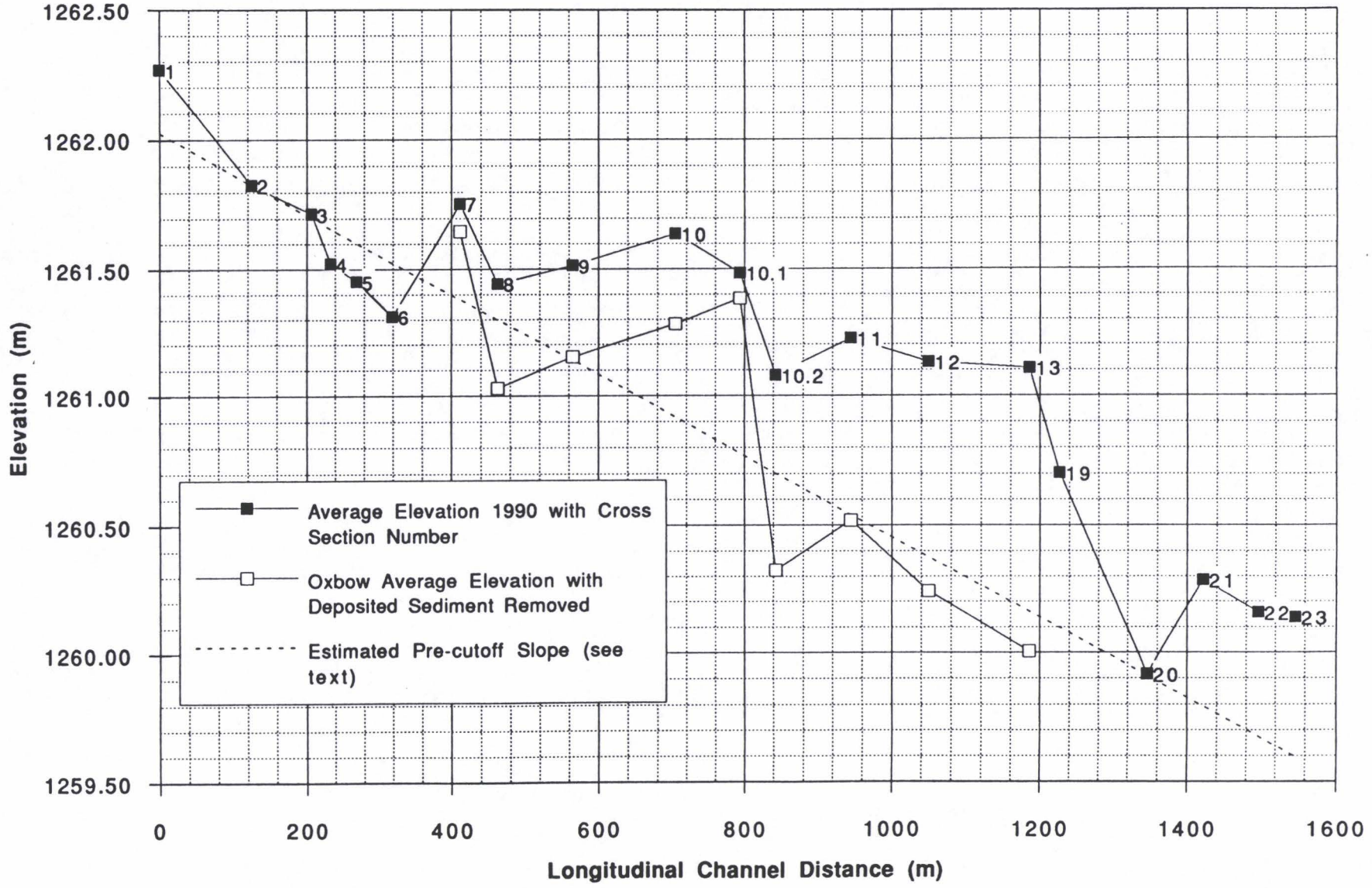
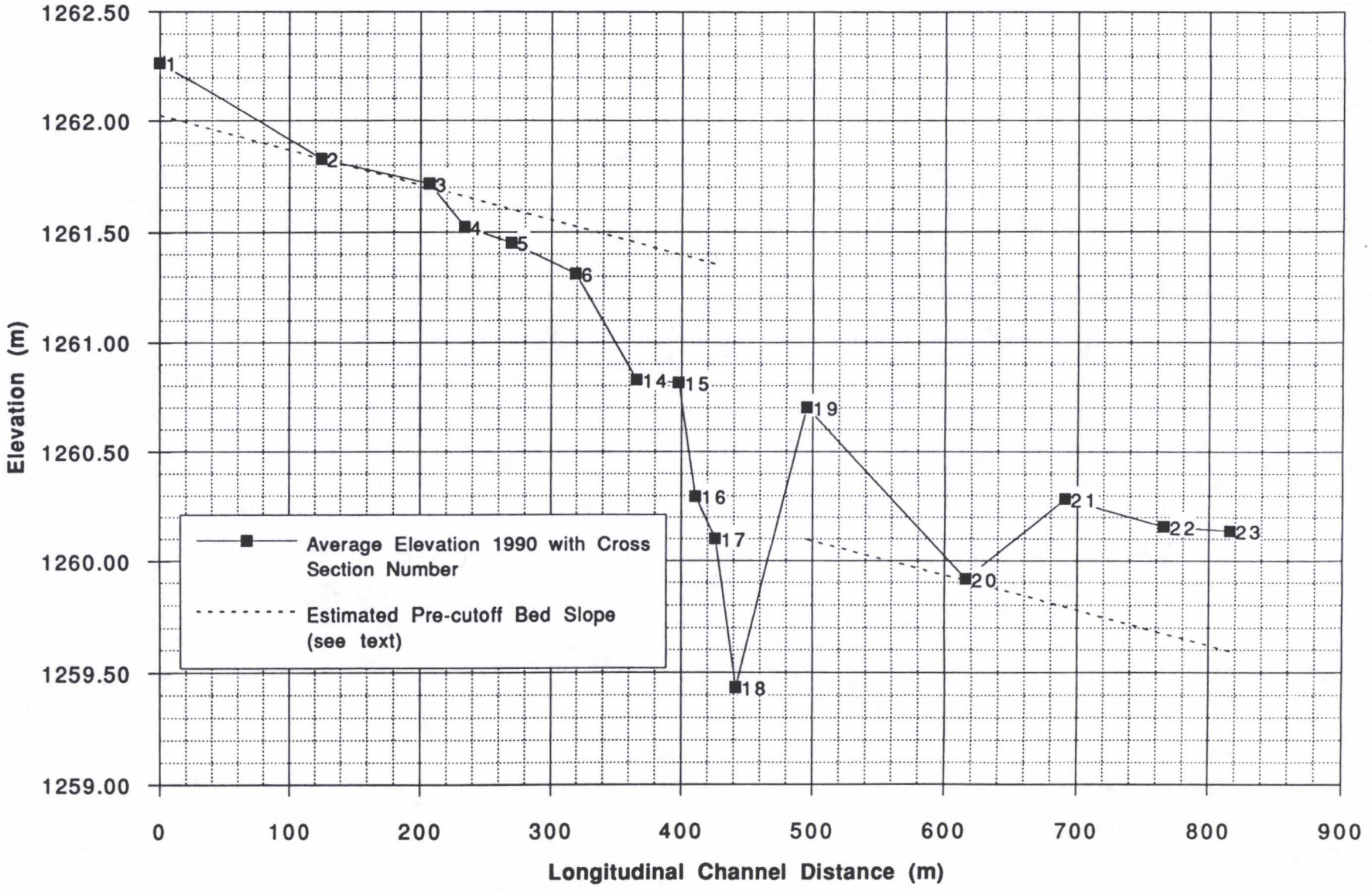


Figure 3.2.2 SFSR Longitudinal Profile of Average Bed Elevation Through Breach



3.3 BREACH

The breach is that portion of the study reach channel that did not exist prior to the cutoff. The breach is composed primarily of decomposed granitic bedrock. The erosion of this material is dependent upon numerous factors including the extent of its decomposition, fracturing, and the mechanical and chemical processes acting upon it. No analytical approach yet devised can sufficiently predict rates of erosion based upon bedrock properties, so direct observations of erosion are necessary to estimate future erosion (Foley, 1980a).

The breach has both widened and deepened in the seventeen years following the cutoff. We have measured the breach width on aerial photographs and from our field survey. The breach elevation was measured in our 1990 survey but no earlier measurements of breach elevation could be located. A Forest Service survey of the breach was done in 1974 (Bert Kulesza, personal communication) but this data could not be located. Breach elevation cannot be accurately estimated from aerial photographs, so we estimated the immediate postcutoff breach elevation as that which produced the correct proportion of flow in the breach and the oxbow in a split-flow hydraulic analysis for the discharge on September 16, 1974, a date for which we have an estimate of the breach discharge and the total river discharge. The split-flow analysis is discussed in Chapter 4. The discharge estimate and the resulting breach elevation are discussed here.

The breach discharge was estimated from a photograph of a man standing in the breach on September 16, 1974 (Figure 2.3.1). A visual estimate was done by dividing the channel into three sections and estimating the width, mean depth, and mean velocity in each subsection. The discharge was estimated to be 1.84 cms (65 cfs) with a maximum error of ±0.57 cms (20 cfs). The total river discharge was estimated by scaling the discharge observed at the Krassel USGS gage on the day of the photograph with a discharge/drainage area relationship that was calibrated using the Krassel and Poverty Flats USGS records for similar discharges. The estimated total river discharge was 3.8 cms. The breach elevation that produced this particular flow split for a total discharge of 3.8 cms and the 1974 post cutoff channel configuration was 1259.5 m with an

error of ± 0.2 m based on the error in estimating the discharge through the breach. A 1974 breach elevation of 1259.5 m corresponds to 50 cm of downcutting in the period from 1974 to 1990.

Both the aerial and oblique photographs show that significant widening of the breach has occurred. This is illustrated in photographs looking downstream through the breach in September 1974 and October 1990 (Figures 3.3.1 and 3.3.2). Table 3.3.2 shows the measured channel widths for the five breach cross sections. Measurements are made from aerial photographs taken on August 13, 1976 and June 6, 1989, and from our field survey of October 1990. The 1990 surveyed widths are generally in good agreement with the 1989 aerial photograph measurements. The exception is that of cross-section 14 which is located in a reach where the channel width is changing rapidly so that a small error in locating the cross section on the photograph could account for a large difference in measured width. From the period 1976 to 1990, the breach widened on the order of 10 to 20 m. At the central portion of the breach through the rock ridge, the breach widened 10 m over this 15 year period.

TABLE 3.3.2 Measurements of Channel Width for Breach Cross-Sections

Cross section	1976 Photo Width (m)	1989 Photo Width (m)	1990 Surveyed Width (m)	Percent Change 1976-1989
14	13	19	24	46
15	11	23	22	109
16	9	30	28	233
17	6	15	16	150
18	14	25	28	79

The volume of sediment eroded from the breach is a key component of the sediment budget for the reach. The volume of sediment was estimated using the average end area method (Moffitt and Bouchard, 1975) for cross sections 14 through 18. The eroded cross sectional area for all sections except cross section 17 was estimated by projecting the existing floodplain level across the cross section. The cross sectional area for section 17 was estimated by assuming that it's precutoff elevation was equal to the precutoff water surface elevation at cross section 6 during the cutoff. This was obtained from the HEC-2 results at 141.6 cms (see Chapter 4 and Appendix D). A

Figure 3.3.1 Photograph looking downstream through breach taken September 16, 1974. The breach width is approximately 5 m (photo courtesy of Bert Kulesza).

Figure 3.3.2 Photograph looking downstream through the breach taken October 6, 1990. The breach width is approximately 16 m.

porosity correction was added (35%) to account for the difference in porosity between unconsolidated sediment and bedrock. The eroded volume of breach material is estimated to be 7,000 m^3.

3.4 UPSTREAM

The impact of the cutoff on the reach upstream of the breach is a primary objective of this study. This reach contains chinook and steelhead spawning gravels in the vicinity of cross section 2. Erosion related to channel adjustments threatens to remove these gravels.

We have more historical information about the upstream sub-reach than any other portion of the study reach. Figure 3.4.1 is a photograph looking upstream from the upstream portion of the breach (photographer standing on bank near XS 15). In the foreground of the photograph are cross sections 14 and 15, the uppermost cross sections of the breach sub-reach where bedrock composes the channel bed. On the right side of the photograph is the upstream portion of the oxbow sub-reach where extensive sand and fine gravel deposition is visible. The most upstream portion of the channel visible in the photograph is near cross section 2.

We have historical surveys of one cross section (XS 2) dating back to 1973, and surveyed annually or biennially since that time. It is the only cross section we have that was surveyed before and after the cutoff. All available surveys for cross section 2, including our 1990 data are plotted on Figure 3.4.2. Figure 3.4.3 is an enlargement of the bed portion of Figure 3.4.2. An initial inspection of Figures 3.4.2 and 3.4.3 suggests that slight downcutting may have occurred since the cutoff, although the pattern of erosion and deposition is complex with bed lowering and raising evident at many points. Additionally, slight channel widening may have occurred, especially on the right side of the channel where a slump block may have fallen into the channel. The total range of elevation change at any point is roughly 20 cm, which is on the order of two to three times the larger grains in the channel.

Figure 3.4.1 Photograph of the upstream sub-reach, looking upstream from the upstream portion of the breach (near XS 15) Taken October 6, 1990.

Figure 3.4.2 Cross Section 2 Surveys, 1973-1990

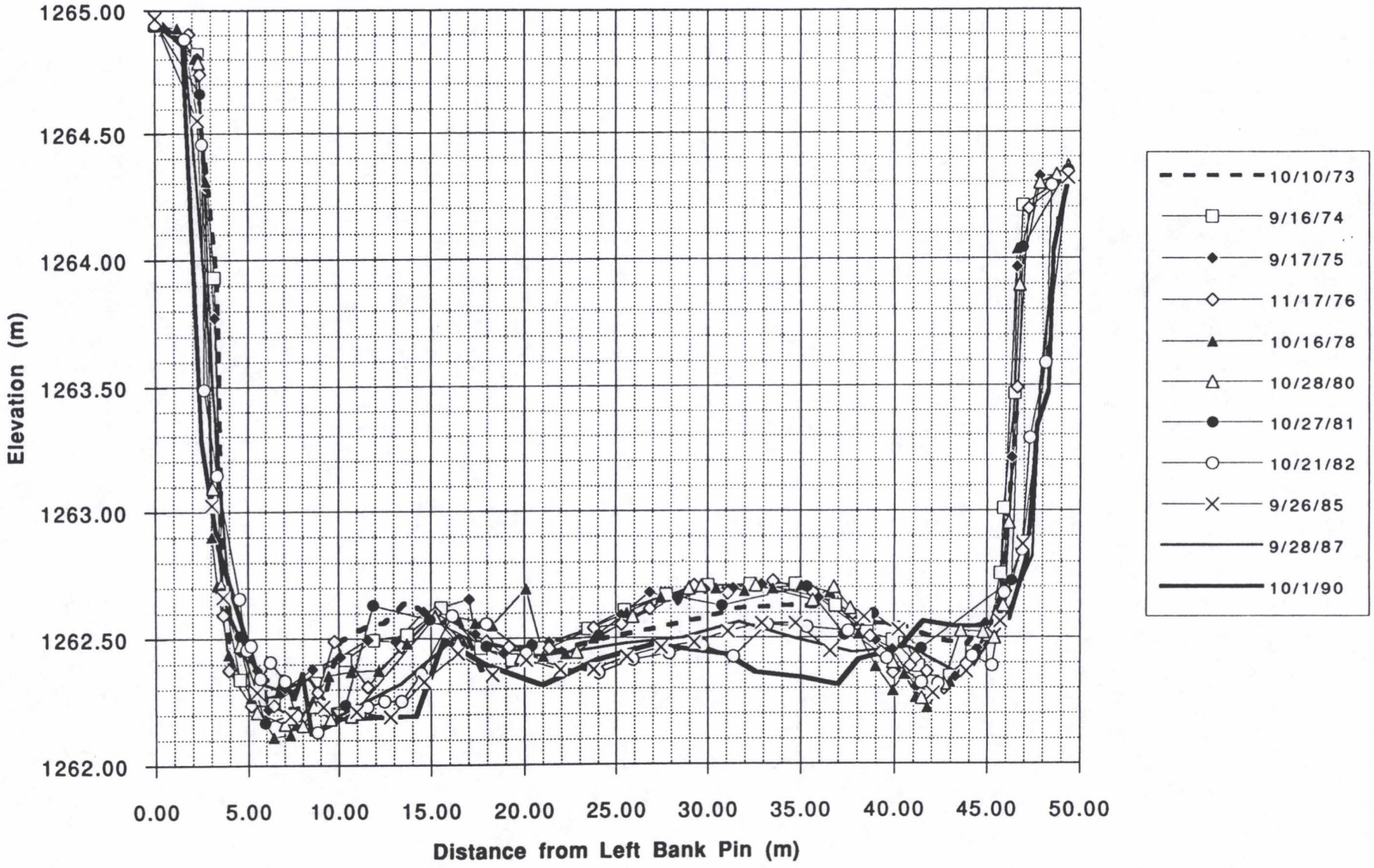


Figure 3.4.3 Bed Portion of Cross Section 2 Surveys, 1973-1990

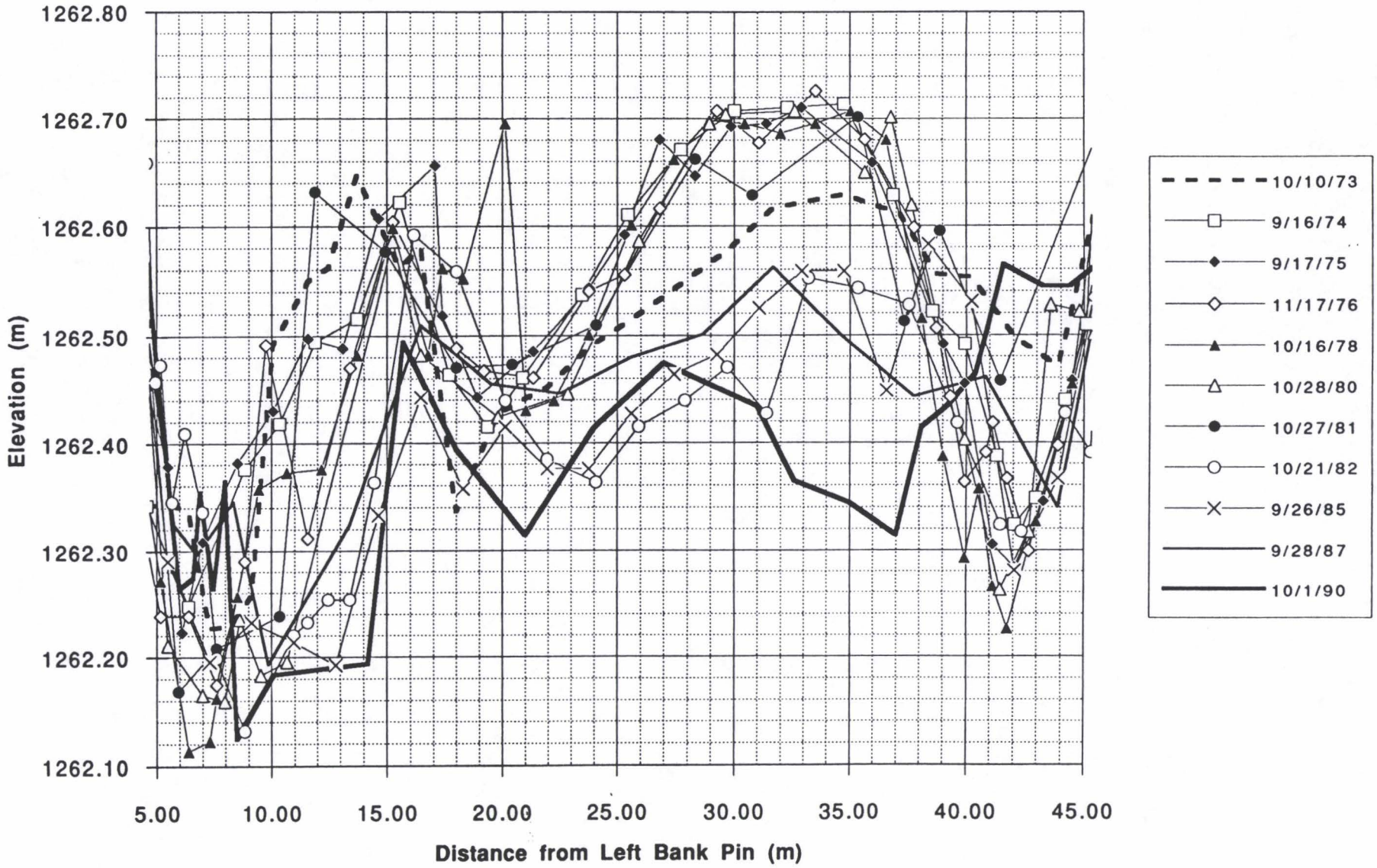


Figure 3.4.4 is a plot of the average and thalweg bed elevation at cross section 2 versus time. The average elevation was computed using a weighted average to avoid bias because of survey point spacing. There is a suggestion that the average bed elevation at cross section 2 dropped on the order of 10 cm between 1973 and 1990. However, the magnitude of bed elevation changes must be compared with the sediment and sedimentary structures at cross section 2. The largest sediment particles are on the order of 10 cm in diameter and bed features (bars, redds) on the order of 10 to 30 cm exist. These bed features are the result of local hydraulics and the construction of redds by spawning chinook salmon and steelhead. Because the measured bed changes are less than the size of the larger grains in the channel, it is not possible to state that the bed has significantly downcut.

Furthermore, changes in bed elevation at cross section 2 must be evaluated in the context of how the SFSR as a whole was changing. There has been a general reduction of bed elevation in the SFSR main channel since the timber harvesting moratorium was imposed in 1965 (Megahan et al., 1980), thus any observed decrease in bed level at cross section 2, if it exists, may be attributed to a general drop in bed elevation and not to the cutoff.

Because cross sections 4, 5, and 6 of the upstream sub-reach are closer to the breach, they have a greater chance of being eroded. Channel erosion may be accomplished through either bank or bed erosion. We measured bank widths on aerial photographs taken in 1965, 1976, and 1989. Within the accuracy of our measurement techniques ($\pm$ 2 m) we were unable to detect any changes in channel width in the aerial photographs, which also agreed with our 1990 survey data and historical Forest Service surveys. Table 3.4.1 shows the widths measured from the aerial photographs and our 1990 ground survey.

Figure 3.4.4 Cross Section 2 Average and Thalweg Bed Elevations, 1973-1990

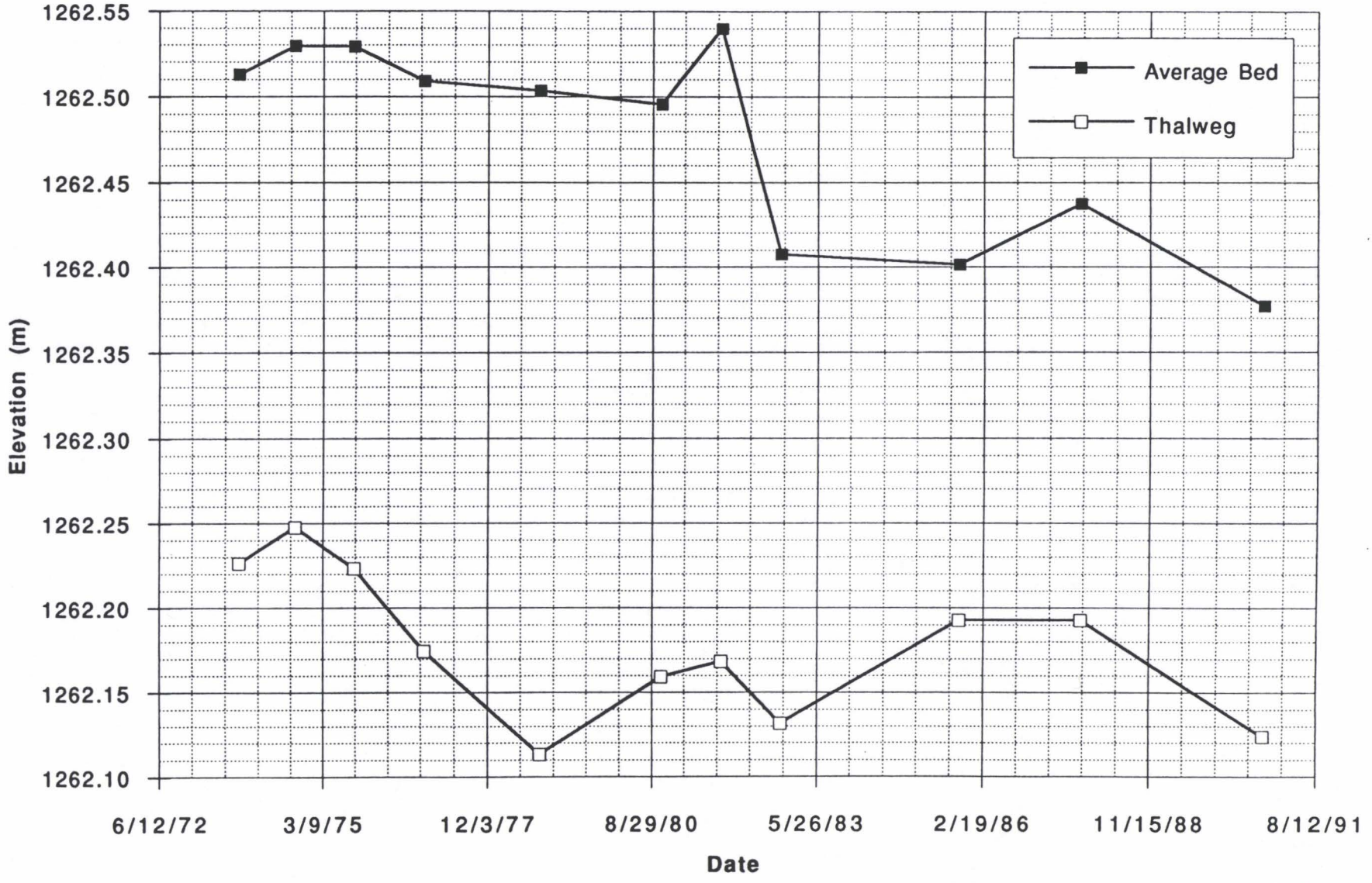


Table 3.4.1 Upstream channel widths at surveyed cross sections.

Cross Section	1965 Photo Width (m)	1976 Photo Width (m)	1989 Photo Width (m)	1990 Surveyed Width (m)
1	*	32	30	33
2	38	41	38	42
3	32	33	34	37
4	32	32	30	33
5	32	32	38	37
6	35	37	34	36

* XS not on photograph used.

Previous surveys of additional cross sections (XS 1, 3,4,5,& 6) in the upstream reach were conducted by the Forest Service and CH2M Hill beginning in the fall of 1986. These surveys show no measurable changes in bed elevation from the fall of 1986 to 1990. We have no direct estimate of bed lowering at cross sections 4, 5, and 6. One means of estimating bed change is to compare our estimate of the precutoff long profile with our surveyed 1990 bed elevations. Any difference would represent postcutoff scour (Figure 3.2.1). The precutoff profile was made to pass through cross section 2, because we have interpreted no downcutting attributable to the cutoff at this cross section. Because we were interested in estimating downcutting between cross sections 4 and 6, those values were not included in developing the precutoff profile. Our estimate of downcutting at cross sections 4 through 6 based upon deviations from the precutoff profile are shown in Table 3.4.2 and are on the order of 15 to 20 cm.. More downcutting is estimated for cross sections closer to the breach (XS 6).

Table 3.4.2 Estimated downcutting at cross sections 4,5, and 6.

Cross section	Bed Downcutting (m)
4	0.14
5	0.15
6	0.21

A comparison of precutoff and postcutoff sediment size estimates suggests that the bed has coarsened at cross section 2. Bed coarsening can be indicative of scour, because, finer sediments can be selectively removed during the scouring leaving behind a coarser bed. The degree of coarsening at cross section 2 is relatively small however, and the estimated values of median grain

size are only approximate. The possible coarsening observed at cross section 2 is not definitive, but supports the idea that a small (<10 cm) amount of scour has occurred since the cutoff. A Forest Service precutoff survey of the bed at cross section 2 (10/10/73 by Kulesza and Dixon) assessed the proportion of sand, gravel, and cobbles at each survey point (n = 27). In 1990 we estimated the median size of the grains coarser than sand. The median size of the gravel (D50 ≈ 22 mm) and cobble (D50 ≈ 90 mm) proportions from the 1973 survey produce an average median grain size of 34 mm for cross section 2. Our 1990 estimate is 43 mm, based on visual estimates at each bed survey point (n = 20).

Additional evidence of bed downcutting in the region between cross sections 4 and 6 is provided by the fact that the bed at cross section 5 is coarser than at cross section 2. The median grain size for cross section 2 is 43 mm, while that at cross section 5 is 74 mm, based on visual estimates of grain size at each survey point. This armoring effect would be greater closer to the breach and should decrease farther upstream. If the bed at cross section 5 had a median grain size on the order of 34 mm, such as we estimate for cross section 2, more than a two-fold bed coarsening would have occurred since the cutoff which is suggestive of bed scour.

Precutoff cross sections have been constructed using our estimates of downcutting and are plotted in Appendix A. These sections are used in the hydraulic modeling described in Chapter 4 for precutoff (1973) and immediate postcutoff conditions (1990). The change in cross sectional area between the precutoff and present conditions was used to estimate the volume of sediment eroded from the upstream sub-reach since the cutoff. We estimate that 1,200 m^3 of sediment has been eroded as a result of the cutoff (average end method, Moffitt and Bouchard, 1975).

Some aspects of the postcutoff channel change in the upstream sub-reach are better known than others. We know from the aerial photographs and historical surveys that no appreciable channel widening has occurred along the upstream sub-reach and that the bed elevation at cross section 2 has been very stable. Our supposition that a small amount of downcutting has occurred between cross sections 4 and 6 is less certain. It is a reasonable location for scour to occur and there is some evidence to suggest that it has, although the magnitude of scour is relatively small.

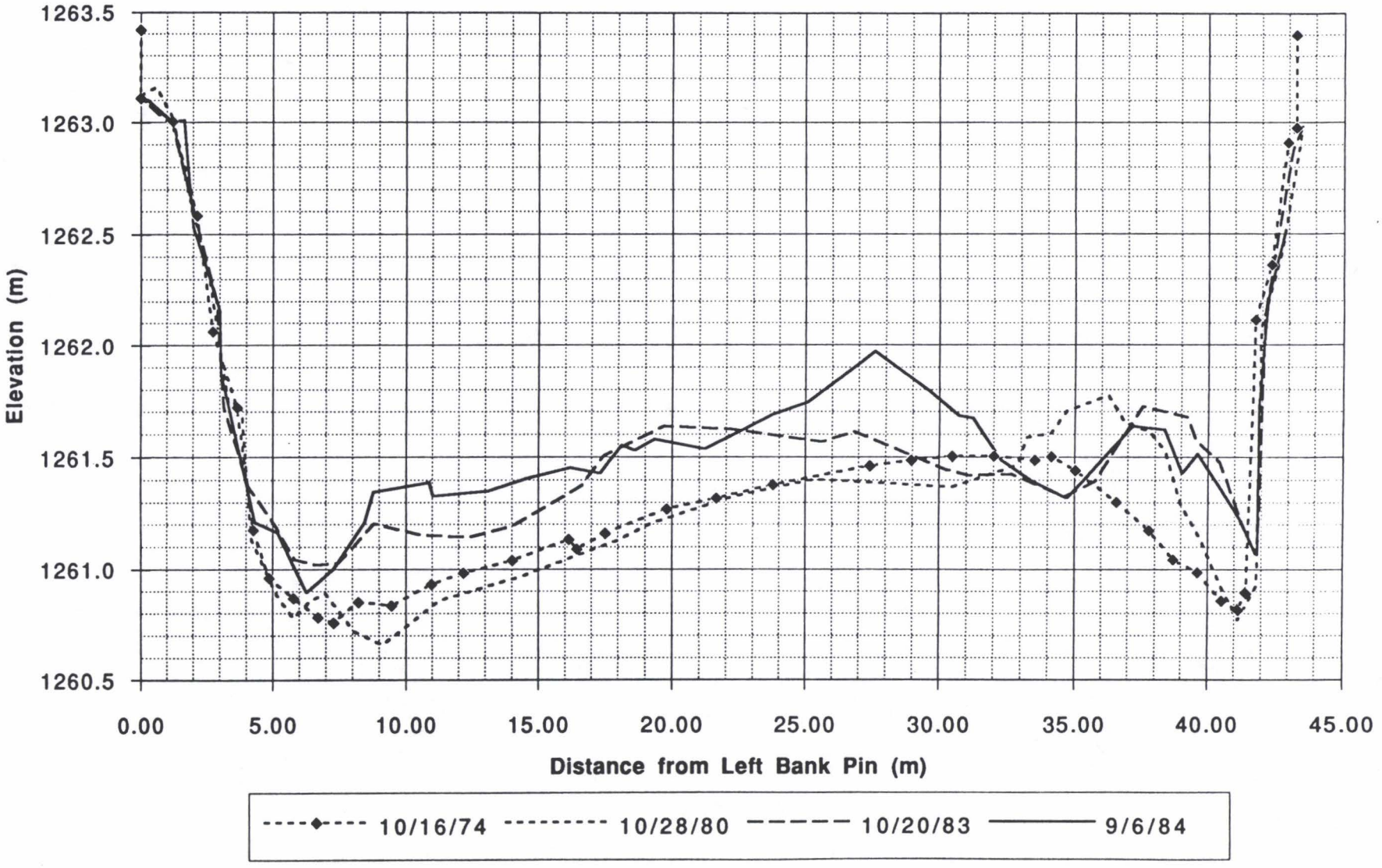
3.5 OXBOW

Sand and fine gravel has deposited in the oxbow since the 1974 cutoff. This is based on field observations of deposited sediment and historical surveys of a single cross section in the downstream end of the oxbow (between XS 11 & 12). Extensive deposition in the oxbow is clearly evident in aerial photographs (see Figures 2.2.1a, b, & c). Figure 3.5.1 is a photograph looking at the upstream end of the oxbow from the right side of the breach.

Figure 3.5.2 shows the surveys for the Forest Service "lower oxbow" cross section. We were unable to precisely locate this cross section in the field but have determined that it is between our cross sections 11 and 12. Since the dominant process in the oxbow is the deposition of sand and fine gravel, the banks are essentially unchanged since the cutoff and no changes in channel width have occurred.

Figure 3.5.1 Photograph looking at upstream of oxbow from right side of breach taken October 6, 1990. Note the extensive deposition in the oxbow.

Figure 3.5.2 Forest Service Surveys of "Lower Oxbow" Cross Section (between XS 11 & 12).



The sediment deposited in the oxbow is fine gravel and sand with a median size of 2 mm. The grain size characteristics of sediment samples are in Appendix B. Oxbow deposition was estimated using the differences between the 1990 cross sections and the 1974 precutoff cross sections (inferred from sand depth measurements). Computation for the entire oxbow sediment storage was done using the average end method (Moffitt and Bouchard, 1975). We estimate the quantity of sediment stored in the oxbow since the cutoff to be 16,500 m^3. This is close to the deposition previously estimated by the Forest Service (~ 14,000 m^3 , Carolyn Bohn, personal communication). The proportion of this sediment that has been deposited since the cutoff is uncertain; but we estimate that at least 50% of it has been deposited since the cutoff.

3.6 DOWNSTREAM

The downstream sub-reach begins where the downstream end of the oxbow rejoins the main channel (XS 19) and extends to the main channel's confluence with Camp Creek. All evidence suggests that this reach has widened and aggraded since the cutoff. Figure 3.6.1 is a photograph of the downstream sub-reach taken May 12, 1991 during the spring snowmelt. The photographer was standing on the top of the left side of the breach looking downstream (near XS 17). The oxbow sub-reach enters the main channel to the left behind the pine trees in the foreground. Notable channel features include the large partially submerged gravel bar and the cut bank with numerous slump blocks on the left side of the channel (from XS 19 to 20). The narrowest portion of the channel visible in the photograph is the location of cross section 20.

Measurements from aerial photographs (Table 3.6.1) and field observations of bank collapse show that the channel downstream of the breach has widened since the cutoff. This widening is most dramatic immediately downstream of the breach at cross section 19 where the width has increased by at least 7 m, although, the presence of collapsing banks (except at cross section 20) suggest that the channel is widening throughout the downstream sub-reach.

Figure 3.6.1 Photograph looking at downstream sub-reach from left side of breach taken May 12, 1991.

Table 3.6.1 Downstream channel widths at surveyed cross sections.

Cross Section	1965 Photo Width (m)	1976 Photo Width (m)	1989 Photo Width (m)	1990 Surveyed Width (m)
19	38	37	45	51
20	25	23	21	26
21	32	34	38	42
22	*	*	*	40
23	*	*	*	41

* XS not on photograph used.

Prior to the cutoff, a large point bar existed on the left side of the channel at cross section 19 (see Figure 2.2.1a). This point bar was completely eroded by 1976 and that location is now a cutbank. The former thalweg at cross section 19 is now the site of a large bar. This bar is visible in the 1976 aerial photographs, although it has grown appreciably since then. We estimate that the volume of sediment in the former point bar is similar to the volume of the postcutoff bar on the right side of the channel. However, the sediment grain size is quite different, with the former point bar composed of sand while the new bar on the right side of the channel is predominantly gravel, with a median surface size between 27 and 41 mm (based on bulk samples and pebble counts, see Appendix B). Similar sediments are obtained from a bulk sample of the thalweg of cross section 19 (D_{50} = 30 mm) and the average of visual estimates across the channel (D_{50} = 35 mm).

The width at cross section 20 has remained constant. This is the narrowest portion of the channel with a present width one-half that of the channel upstream (XS 19). This constriction is an area of locally high velocities and visual estimates of grain size show that it is the coarsest cross section in the downstream reach with an average median grain size of 51 mm. Aerial photograph measurements suggest that cross section 21 has widened by at least 2 m. Although we did not measure the widths from photographs for cross sections 22 and 23, we believe that their widths have also increased, based upon observations of numerous bank slump blocks.

We postulate that this channel widening is in response to bed aggradation since the cutoff. An aggrading bed reduces a channel's flow capacity and widening occurs to adjust the channel's size to its flow regime. In addition to the channel widening, we observed an increase in depositional

bars between cross sections 21 and 23. The volumetric increase in bars is difficult to quantify because the aerial photographs available were taken at different river discharges.

We have no quantitative measurements of how the bed elevation of the channel downstream of the breach has changed since the cutoff because there are no survey data prior to that of CH2M Hill (1987) from the fall of 1986. Although we were unable to locate their downstream cross sections, a comparison of the longitudinal profiles of average bed elevation using their data and our surveys suggest that the mean bed elevation has not changed from the fall of 1986 to 1990, a period of below average flows for the SFSR.

We have estimated downstream aggradation from deviations in the present longitudinal profile from the estimated precutoff profile (Figure 3.2.1). Those estimates range from no aggradation at cross section 20 to nearly 70 cm of aggradation at cross section 23 and are listed in Table 3.6.2.

Table 3.6.2 Downstream sub-reach inferred bed aggradation

XS	Bed Aggradation (m)
19	0.40
20	0
21	0.50
22	0.59
23	0.68

Our estimates of downstream bed aggradation were used to construct precutoff and immediate postcutoff cross sections for the hydraulic modeling described in Chapter 4. Plots of these cross sections are included in Appendix A. We estimated the maximum volume of downstream deposited sediment to be 5,000 m^3, using these estimated precutoff cross sections and the average end method (Moffitt and Bouchard, 1975).

As in the other sub-reaches of the study reach, some of our estimates of channel change are more conjectural than others. It is clear from the aerial photographs that channel widening has occurred in the downstream sub-reach. It appears that bed aggradation has occurred, based on the observed channel widening and bar development. The quantity of bed aggradation and sediment deposition, however, is somewhat uncertain.

3.7 SEDIMENT BUDGET

We have constructed a sediment budget for the study reach which accounts for erosion upstream and in the breach, and deposition downstream and in the oxbow. These values are also compared with an estimate of sediment throughput through the reach. This sediment budget is a tool to estimate changes in sediment load downstream of the study reach as a result of the cutoff. The net impact of the cutoff on the sediment budget of the study reach is determined by combining the change in sediment storage for each of the four sub-reaches. Sediment storage in each of the four sub-reaches is described in Table 3.7.1.

Table 3.7.1 SFSR Oxbow Reach Sediment Storage

Sub-reach	Change in Sediment Storage (m^3)	Description
Breach	-7,000	Estimated bedrock removed from XSs 14, 15, 16, 17, & 18 with porosity correction.
Upstream	-1,200	Inferred downcutting of XSs 4, 5, & 6 from channel profile.
Oxbow	+8,300 to +16,500	Filling in of oxbow, estimated from probing accumulated sediment for 9 cross sections.
Downstream	0 to +5,000	Inferred bed aggradation from channel profile. Quantity is uncertain.
Entire Study Reach	+100 to +13,300	

Sediment supply downstream of the study reach has not increased as a result of the cutoff. We estimated that 16,500 m^3 of sediment is presently stored in the oxbow, however, up to 50% of that sediment may have been deposited prior to the cutoff so we have estimated oxbow deposition to be between 8,300 and 16,500 m^3. Because the quantity of downstream bed aggradation is uncertain,

we have expressed it as a range from no deposition to 5,000 m^3. On a sub-reach basis, the breach and upstream sub-reaches have both been net exporters of sediment and the oxbow has been a sink. The supply of sediment to the downstream reach decreased by up to 8,300 m^3 (computed by subtracting sediment stored in oxbow from that eroded upstream and in the breach).

The net impact of the cutoff on the study reach sediment budget must be put into the context of the overall sediment moving through the breach. We can estimate within an order of magnitude the sediment transport through the reach based upon sediment measurements made at the Krassel USGS gaging station (Williams et al., 1989). Sediment transport since the cutoff has been estimated using a total sediment rating curve generated for Krassel measurements (Figure 3.7.1) and historical discharges for Krassel scaled for the study reach proportional to drainage area. We have only used discharges greater than 20 cms (730 cfs) at the oxbow. Although suspended sediment and slight bedload transport of sand occurs at lesser discharges, such transport was not computed. Thus, our transport estimates should be considered conservative (i.e. we have underestimated transport). For the purpose of determining whether the sediment storage in the study reach is a large or small proportion of the transport, this approach is adequate. We have made several important assumptions including assuming that the study reach sediment rating curve is similar to that at Krassel and that the sediment rating curve has not greatly changed over the period 1974 to 1990. These assumptions are reasonable for an order of magnitude calculation which is adequate for comparing sediment storage to sediment load. To convert from mass to volume, we assumed the sediment was quartz density and had a porosity of 0.35.

Using this method we computed the sediment transport through the study reach to be 86,000 m^3 from 1974 to 1990. Table 3.7.1 shows estimates for individual water years. Table 3.7.2 presents the study reach storage as a proportion of the sediment throughput. If the sediment transport estimate may be in error by a factor of two, the net effect of the study reach has been to trap up to 31 percent of the sediment delivered to the reach, with the most likely value being roughly 10 %.

Figure 3.7.1 Total sediment rating curve (based on Krassel measurements of Williams et al., 1989)

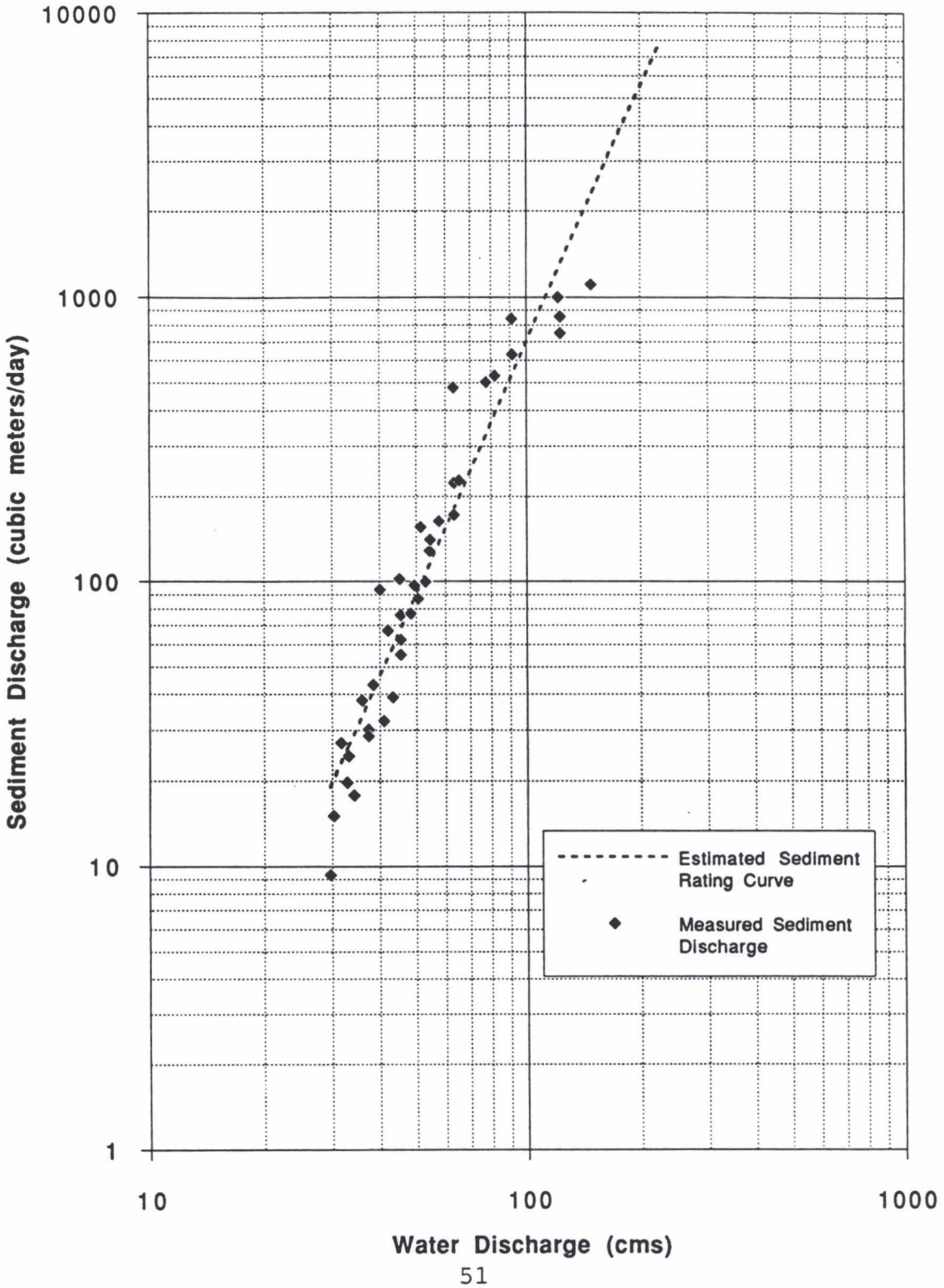


Table 3.7.1 Estimated total sediment transport through study reach 1974-1990 for days with discharge greater than 28 cms (1000 cfs) at Krassel.

Water Year	Days above 28 cms	Estimated Sediment Transport (m^3)	Notes
1974	104	20295	
1975	60	4235	
1976	62	4375	
1977	0	0	No high flows in WY 1977.
1978	84	3716	
1979	33	977	
1980	78	3920	
1981	64	2680	
1982	87	10509	
1983	77	8377	
1984	68	6280	
1985	50	1137	
1986	71	7565	
1987	*	5070	Missing data, used mean of other years.
1988	*	5070	Missing data, used mean of other years.
1989	56	1559	
1990	30	418	
TOTAL 1974-1990		**86184**	

Table 3.7.2 Proportion of sediment throughput stored in study reach.

	Proportion of Sediment Throughput Stored in Study Reach	
Sediment transport through study reach, 1974-1990	**Low Estimate of Net Storage 100 m^3**	**High Estimate of Net Storage 13,300 m^3**
43,000 m^3	0.2 %	31 %
86,000 m^3	0.1 %	15 %
172,000 m^3	0.06 %	8 %

4. NUMERICAL HYDRAULIC MODELING

4.1 INTRODUCTION

Water surface profiles models of the South Fork Salmon River (SFSR) Oxbow and Cutoff were constructed to estimate the changes in flow distribution, boundary shear stress, and water surface elevations induced by the breaching of the oxbow. Three time specific scenarios were examined:

(1) Existing conditions based on field surveys made in 1990 and 1991;

(2) Precutoff conditions in 1974, just prior to creation of the breach; and

(3) Immediate postcutoff conditions in 1974, just after creation of the breach and before filling in of the oxbow.

The U.S. Army Corp of Engineers Water Surface Profiles model (HEC-2) was used to calculate water surface elevations. A description of the HEC-2 model is given below. This is followed by a description of the steps taken to prepare the three modeling scenarios. The results of this analysis are discussed in Chapter 5.

4.2 WATER SURFACE PROFILE MODELING

HEC-2 Water Surface Profile Model

HEC-2 is a computerized program for calculating water surface profiles for steady, gradually varied flow in natural or man-made channels. It was developed by the U.S. Army Corp of Engineers, Hydrologic Engineering Center (HEC) at Davis, California in 1964 and has been continuously maintained and updated since that time. The computational procedure used by HEC-2 is based on the Standard Step Method. In this method, water surface elevation and other pertinent hydraulic parameters are calculated by iterative solution of the one-dimensional energy equations with friction losses evaluated by the Manning equation. Complete documentation on the use of the program, input data preparation, and summary of modeling capabilities is contained in the HEC-2 User's Manual (Hydrologic Engineering Center, 1990).

Modeling Options Used for the SFSR Oxbow and Cutoff

Modeling of the SFSR Oxbow and Cutoff followed accepted HEC-2 methodology for modeling natural stream channels. However, because HEC-2 has numerous optional capabilities, it is important to note specific options used to model the SFSR Oxbow and Cutoff:

(1) Subcritical flow was assumed. This was verified by monitoring the Froude Number at each cross section for each scenario.

(2) Input and output were in metric units.

(3) Manning's roughness values were varied vertically with depth.

(4) The friction slope equation was selected by HEC-2 on the basis of profile type. In cases where the friction slope at the current cross section is greater than the preceding cross section, the average friction slope is used for the reach. Otherwise, the friction slope is calculated using an harmonic mean. Evidence documented in the HEC-2 User's Manual indicates that this produces more accurate results.

Split Flow Modeling

A special feature of the SFSR is the flow split between the Oxbow and the Cutoff. This requires special treatment as HEC-2 is not specifically designed to handle flow separation over an extended length (more than several cross sections). Fortunately, guidelines for modeling this type of flow split (referred to as Island Split Flow) have been established and are documented in an HEC training manual (Montalvo, 1982). The basis of the procedure is that the energy loss for the two channels must be equivalent. In order to determine the flow split for a given discharge, initially the flow is arbitrarily apportioned between the two channels. Water surface profiles are computed for each channel starting at the cross section where the flow divides to the point where the flows are recombined. These computations are repeated with new flow proportions until the water surface elevations at the point of recombination are in agreement for each channel of the flow split.

Input Data Collection and Preparation

The first step in the modeling procedure is to collect and process data on stream geometry, roughness, and flow conditions. Surveys were performed in 1990 and 1991 to measure stream cross sections, stream thalweg profiles, water surface profiles, and to collect data on bed roughness and composition (see Chapter 2). The cross sections were plotted and checked. Then the sections were converted to HEC-2 format. Calibration discharges in the SFSR main stem were estimated using flow measurements at the USGS gage at the Krassel Ranger Station noted during the surveys. The discharge values at the Krassel gage were reduced in proportion to the differences in areas between the Oxbow drainage area (622 km^2) and the Krassel drainage area (855 km^2).

Initial estimates of Manning's n were made for each cross section using the methodology described by Jarrett (1985). In this procedure, Manning's n is calculated by adding adjustment values reflecting channel variations to a base Manning's n value for the channel. The adjustment equation is:

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)\, m \qquad \text{(Eq. 4.2.1)}$$

where

n_0 is the base n value for a straight uniform channel;

n1 is an additive value due to cross section irregularity;

n_2 is an additive value due to variations in the channel;

n_3 is an additive value due to obstructions;

n_4 is an additive value due to density and occurrence of vegetation; and

m is a multiplier used to reflect the degree of meandering.

Jarrett (1985) presents tables to guide selection of values for n_1, n_2, n_3, n_4, and m. Base Manning's n values were determined by field inspection. Minimal adjustments were required for vegetation as the channel banks are sparsely vegetated. There were significant adjustments made for cross section irregularities, variation in channel, and obstructions. These adjustments were

especially critical at low flow. The value of Manning's n was varied with depth below the measured high flow elevations made in 1991. This was important because flow depths for the low flow measurements were within the scale of the roughness elements and channel roughness changed very rapidly with depth. At the high flow measurements, the depths were much greater than the roughness lengths. At discharges at and above the high flow measurements, the cross sections were inundated to near bank full and roughness changes were assumed to be negligible.

4.3 MODELING OF EXISTING CONDITIONS (1990-1991)

Introduction

An analysis of existing conditions, reflecting the 1990 and 1991 surveys, was made for two purposes. The first purpose was to calibrate and debug a HEC-2 data set for the SFSR Oxbow and Cutoff. This included refinement of the original estimates of Manning's n values to match measured water surface profiles and error checking of cross section measurements. The second purpose was to develop an understanding of existing flow conditions and to evaluate long term hydraulic effects of the opening of the Cutoff on channel stability.

Calibration

Surveyed water surface profiles were available for two discharges: (1) 2.00 cms (71 cfs) measured in early October 1990; and (2) 18.95 cms (669 cfs) measured 10 May 1991. The surveyed water surface elevations were used to assign starting water surface elevations at Cross Section 23, the furthest downstream cross section. Through iterative HEC-2 runs, Manning's n values and the flow split were adjusted until a good agreement was reached between measured elevations and model results. Table 4.3.1 provides a tabular listing of the measured and computed water surface elevations. Figure 4.3.1 shows the calibrated water surface profiles. A copy of the HEC-2 dataset for existing conditions is included in Appendix C.

Figure 4.3.1 Calibration Plot of Surveyed and Modeled Water Surfaces

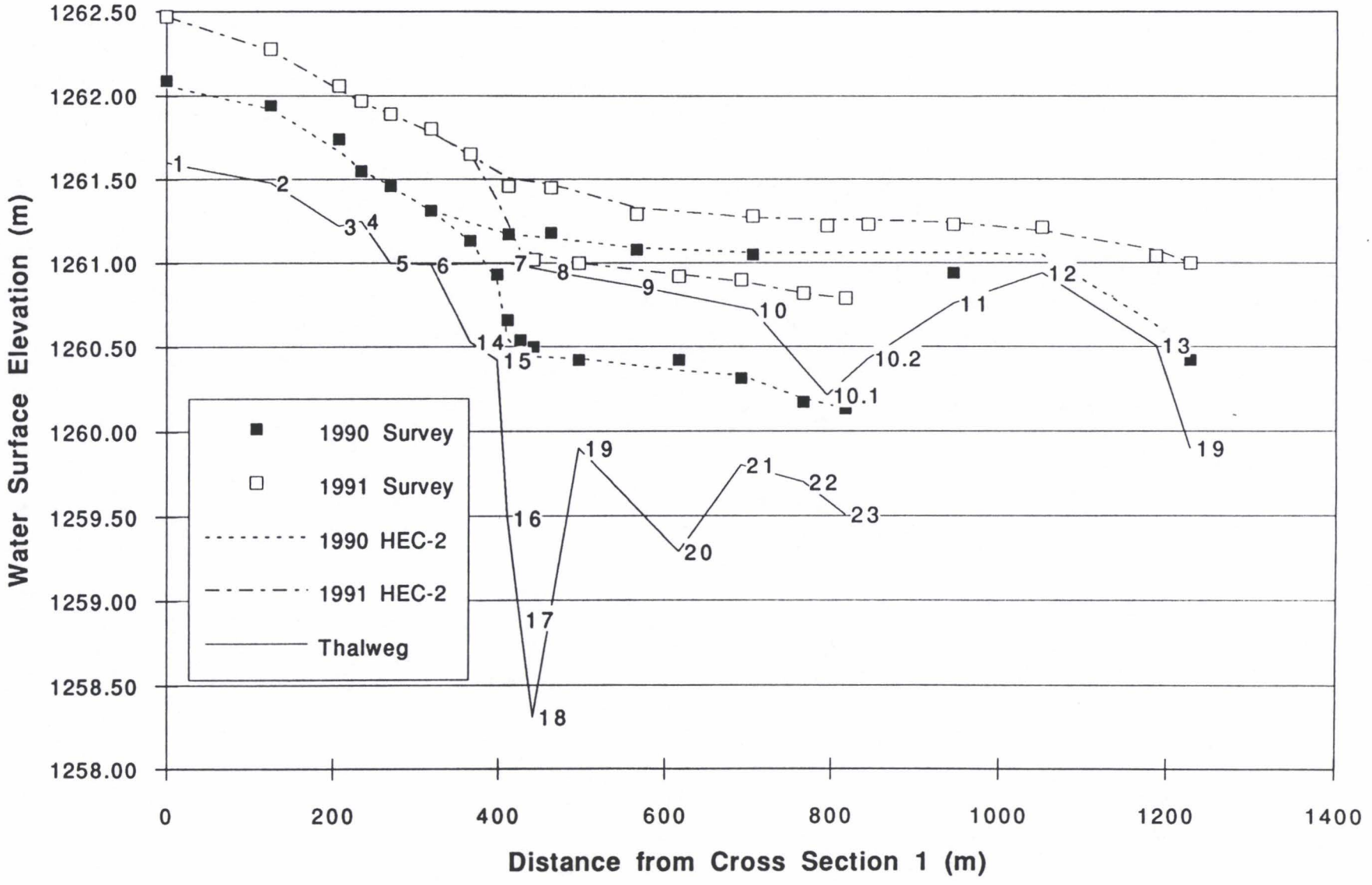


Table 4.3.1 Calibrated and surveyed water surface profiles

Cross Section	Station (m)	Surveyed Water Surface Elevation (m)		HEC-2 Computed Water Surface Elevation (m)		Difference (m)	
		1990	1991	1990	1991	1990	1991
Main and Cutoff Channel							
1	0	1262.09	1262.47	1262.06	1262.47	-0.03	0.00
2	125	1261.94	1262.28	1261.92	1262.27	-0.02	-0.01
3	207	1261.74	1262.06	1261.67	1262.04	-0.07	-0.02
4	234	1261.55	1261.97	1261.56	1261.96	0.01	-0.01
5	270	1261.46	1261.89	1261.46	1261.89	0.00	0.00
6	319	1261.31	1261.80	1261.31	1261.78	0.00	-0.02
14	366	1261.13	1261.65	1261.13	1261.65	0.00	0.00
15	398	1260.93	NA	1260.89	1261.37	-0.04	NA
16	411	1260.66	NA	1260.55	1261.24	-0.11	NA
17	426	1260.54	NA	1260.46	1261.07	-0.08	NA
18	442	1260.50	1261.02	1260.44	1261.06	-0.06	0.04
19	496	1260.42	1261.00	1260.43	1261.00	0.01	0.00
20	616	1260.42	1260.92	1260.36	1260.93	-0.06	0.01
21	691	1260.31	1260.90	1260.33	1260.89	0.02	-0.01
22	766	1260.17	1260.82	1260.19	1260.82	0.02	0.00
23	816	1260.13	1260.79	1260.13	1260.79	0.00	0.00
Oxbow Channel							
6	319	1261.31	1261.80	1261.31	1261.78	0.00	-0.02
7	412	1261.17	1261.46	1261.17	1261.51	0.00	0.05
8	463	1261.18	1261.45	1261.15	1261.47	-0.03	0.02
9	565	1261.08	1261.29	1261.09	1261.33	0.01	0.04
10	705	1261.05	1261.28	1261.06	1261.27	0.01	-0.01
10	794	NA	1261.22	1261.06	1261.26	NA	0.04
10	843	NA	1261.23	1261.06	1261.26	NA	0.03
11	945	1260.94	1261.23	1261.06	1261.24	0.12	0.01
12	1050	NA	1261.21	1261.05	1261.19	NA	-0.02
13	1186	NA	1261.04	1260.63	1261.08	NA	0.04
19	1227	1260.42	1261.00	1260.43	1261.00	0.01	0.00

Rating Curves for Existing Conditions

Once the data set was calibrated, a series of runs were made to develop rating curves for series of discharge values. Figure 4.3.2 and Table 4.3.2 display the water surface profiles computed for existing conditions at various flows.

Figure 4.3.2 Existing (1990) Water Surface Profiles

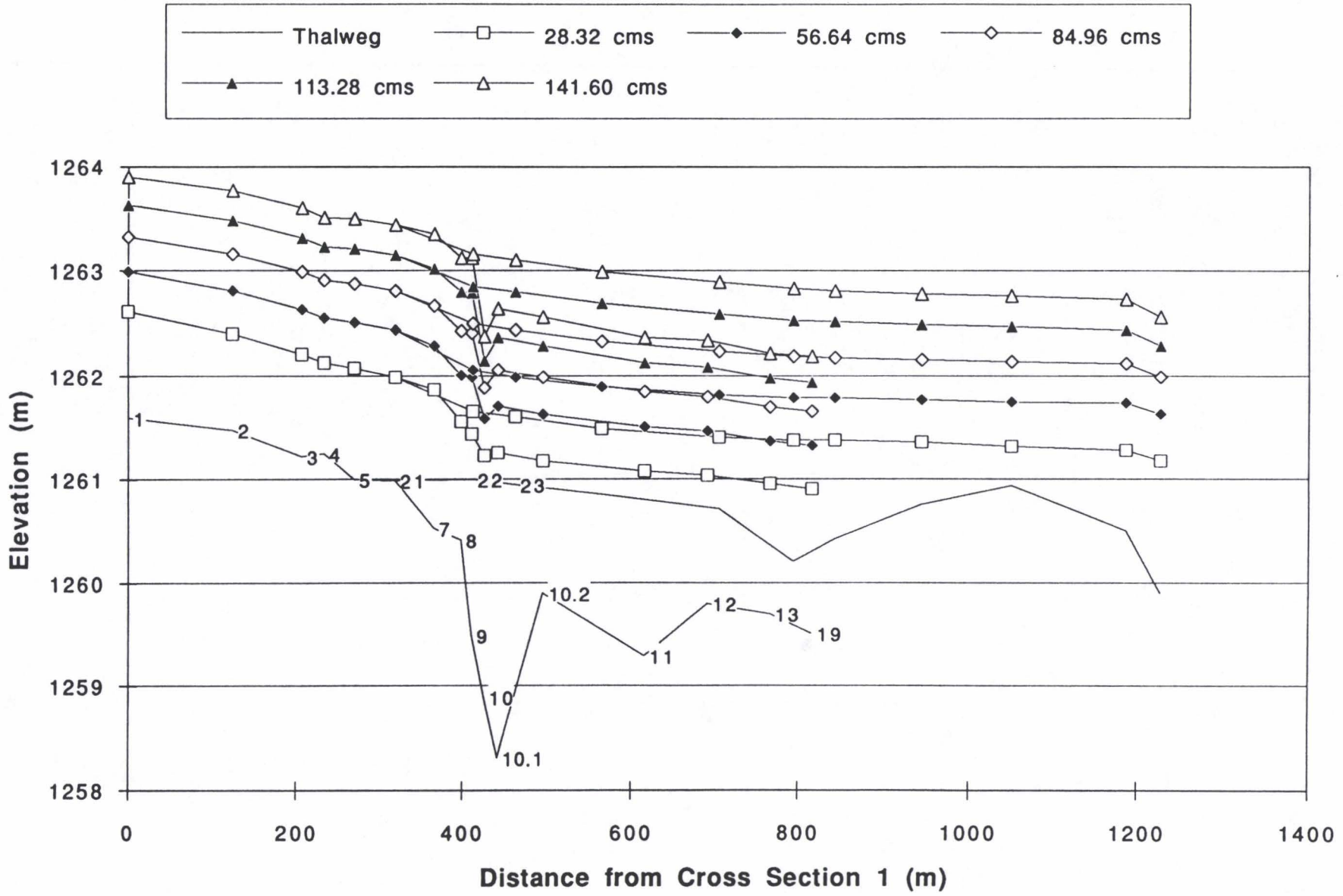


Table 4.3.2 Water surface profiles for existing conditions (1990).

Cross Section	River Station (m)	Water Surface Elevation (m) at Following Discharges							
		2.832 cms (100 cfs)	7.08 cms (250 cfs)	14.16 cms (500 cfs)	28.32 cms (1000 cfs)	56.64 cms (2000 cfs)	84.96 cms (3000 cfs)	113.28 cms (4000 cfs)	141.60 cms (5000 cfs)
Main and Cutoff Channel									
1	0	1262.11	1262.26	1262.41	1262.61	1262.99	1263.32	1263.63	1263.90
2	125	1261.96	1262.10	1262.22	1262.40	1262.81	1263.16	1263.48	1263.77
3	207	1261.72	1261.86	1261.99	1262.21	1262.63	1262.99	1263.31	1263.60
4	234	1261.60	1261.75	1261.90	1262.13	1262.55	1262.91	1263.23	1263.51
5	270	1261.50	1261.67	1261.83	1262.08	1262.51	1262.88	1263.21	1263.50
6	319	1261.36	1261.57	1261.75	1261.99	1262.44	1262.81	1263.15	1263.44
14	366	1261.21	1261.44	1261.63	1261.87	1262.29	1262.67	1263.02	1263.35
15	398	1260.99	1261.16	1261.34	1261.56	1262.01	1262.43	1262.80	1263.12
16	411	1260.65	1260.90	1261.13	1261.44	1261.99	1262.41	1262.79	1263.12
17	426	1260.54	1260.77	1260.97	1261.23	1261.59	1261.89	1262.15	1262.38
18	442	1260.51	1260.74	1260.95	1261.26	1261.71	1262.06	1262.37	1262.64
19	496	1260.49	1260.70	1260.90	1261.18	1261.63	1261.99	1262.29	1262.56
20	616	1260.42	1260.62	1260.81	1261.08	1261.51	1261.85	1262.13	1262.37
21	691	1260.38	1260.56	1260.76	1261.04	1261.47	1261.80	1262.09	1262.34
22	766	1260.23	1260.43	1260.67	1260.96	1261.37	1261.70	1261.98	1262.22
23	816	1260.13	1260.37	1260.62	1260.91	1261.33	1261.66	1261.94	1262.19
Oxbow Channel									
6	319	1261.36	1261.57	1261.75	1261.99	1262.44	1262.81	1263.15	1263.44
7	412	1261.23	1261.41	1261.53	1261.66	1262.06	1262.50	1262.85	1263.16
8	463	1261.21	1261.38	1261.49	1261.61	1261.99	1262.44	1262.80	1263.10
9	565	1261.13	1261.26	1261.34	1261.49	1261.90	1262.33	1262.69	1262.99
10	705	1261.09	1261.21	1261.28	1261.41	1261.82	1262.24	1262.59	1262.89
10.1	794	1261.08	1261.20	1261.26	1261.38	1261.79	1262.19	1262.53	1262.83
10.2	843	1261.08	1261.20	1261.26	1261.38	1261.79	1262.18	1262.52	1262.81
11	945	1261.08	1261.19	1261.25	1261.36	1261.77	1262.16	1262.49	1262.78
12	1050	1261.07	1261.14	1261.18	1261.32	1261.75	1262.14	1262.47	1262.76
13	1186	1260.67	1260.83	1260.98	1261.28	1261.74	1262.12	1262.44	1262.73
19	1227	1260.49	1260.70	1260.90	1261.18	1261.63	1261.99	1262.29	1262.56

4.4 MODELING OF PRECUTOFF CONDITIONS (1973)

Dataset Construction

An analysis was made of Precutoff hydraulics in the SFSR Oxbow in order to provide a baseline for evaluating the effects of the opening of the Cutoff. This required the development of a HEC-2 dataset that reflected the preexisting conditions. Because there were no surveys of the precutoff channels available, cross sections for precutoff conditions were estimated by

modification of the surveyed cross sections. The rationale for changing individual cross sections is discussed in Chapter 3. The following discussion highlight the individual modifications:

(1) The breach (cross sections 14, 15, 16, 17, & 18) was removed from the dataset. All flow was routed through the Oxbow.

(2) The Oxbow cross sections (7, 8, 9, 10, 10.1, 10.2, 11, 12, & 13) were "desanded". The purpose of the desanding was to restore the cross sections to their original configuration before deposition had occurred. The precutoff cross section morphology was estimated from field measurements performed with a steel probe. The surveyed cross sections were adjusted to reflect the bed indicated by the probe measurements. Channel roughness values were adjusted to reflect average roughness values found in the upstream (cross sections 1-6) and downstream (cross sections 19-23) reaches.

(3) As described in Chapter 3, we estimated that some downcutting has occurred in the upstream reach. Cross sections 4, 5, & 6 were raised 14, 15, & 21 cm. respectively to reflect the precutoff elevations. The elevations of the in-channel stations of the cross sections were calculated by reducing the depth at each cross section station below the banks stations in proportion to the change in thalweg depths.

(4) As described in Chapter 3, there is some evidence that bed aggradation has occurred in the downstream reach. Accordingly, cross sections 19, 21, 22, 23 were lowered 40, 50, 59, & 68 cm. respectively. Additionally, the shape of cross section 19 was adjusted to reflect the shifting of a point bar across the channel. The new cross sections were calculated by lowering the in-channel elevations in proportion to the change in thalweg depths below the bank elevations.

Rating Curves for Precutoff Conditions

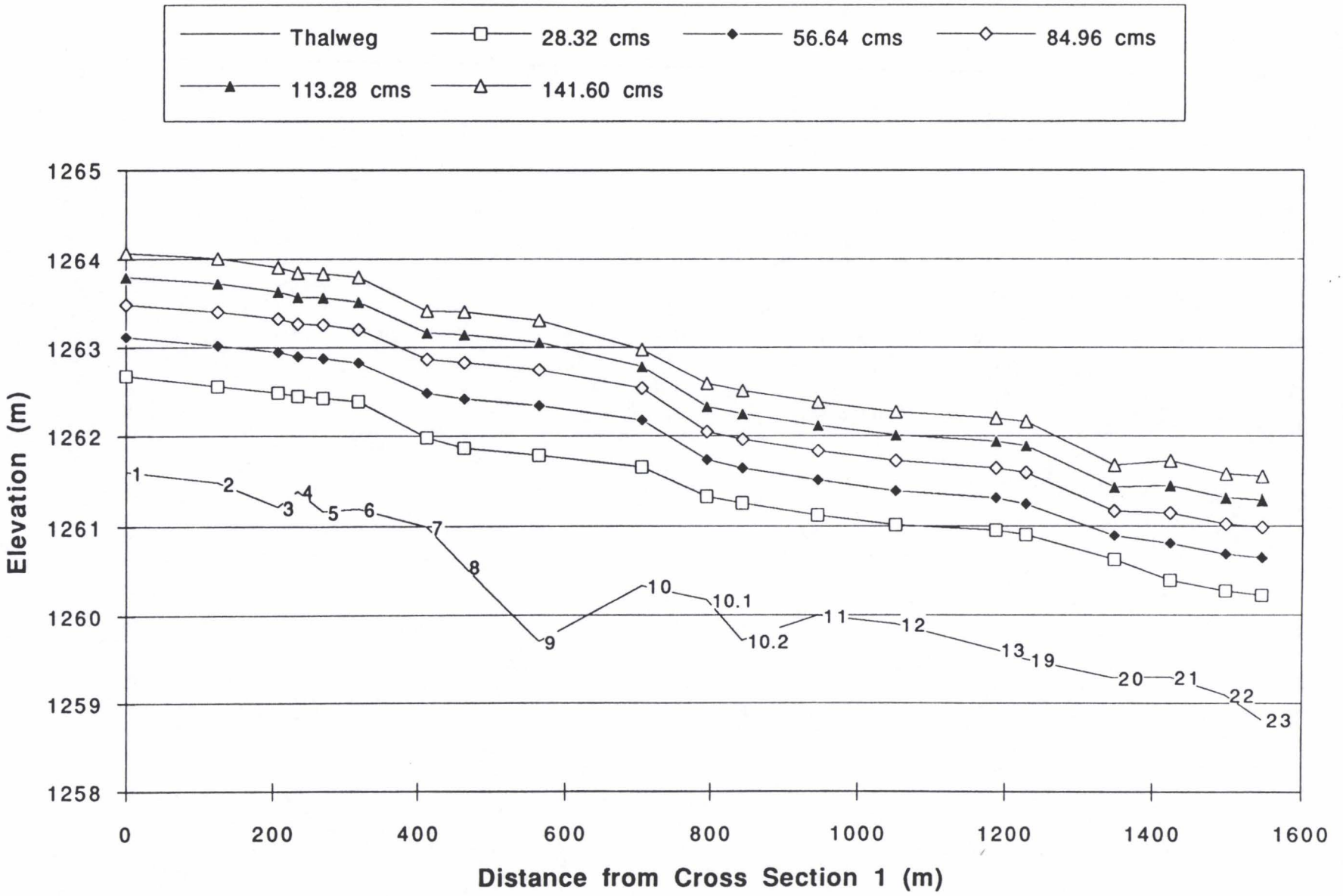
After the HEC-2 dataset had been adjusted, it was run and checked for errors. A copy of the HEC-2 dataset for precutoff conditions is included in Appendix C. A series of runs were then

made to develop rating curves for various discharge values. Table 4.4.1 presents a rating table for precutoff conditions. Figure 4.4.1 displays the water surface profiles for various flows.

Table 4.4.1 Water surface profiles for precutoff conditions (1973).

Cross Section	River Station (m)	Water Surface Elevation (m) at Following Discharges							
		2.832 cms (100 cfs)	7.08 cms (250 cfs)	14.16 cms (500 cfs)	28.32 cms (1000 cfs)	56.64 cms (2000 cfs)	84.96 cms (3000 cfs)	113.28 cms (4000 cfs)	141.60 cms (5000 cfs)
1	0	1262.11	1262.26	1262.41	1262.68	1263.12	1263.49	1263.80	1264.07
2	125	1261.97	1262.10	1262.25	1262.56	1263.02	1263.41	1263.73	1264.01
3	207	1261.81	1261.98	1262.17	1262.49	1262.95	1263.33	1263.64	1263.91
4	234	1261.76	1261.94	1262.14	1262.45	1262.90	1263.27	1263.58	1263.85
5	270	1261.71	1261.91	1262.11	1262.43	1262.88	1263.26	1263.57	1263.84
6	319	1261.66	1261.86	1262.07	1262.39	1262.83	1263.21	1263.52	1263.80
7	412	1261.36	1261.56	1261.72	1261.98	1262.48	1262.87	1263.17	1263.42
8	463	1261.04	1261.22	1261.46	1261.86	1262.42	1262.83	1263.15	1263.41
9	565	1260.85	1261.11	1261.38	1261.78	1262.34	1262.75	1263.06	1263.31
10	705	1260.79	1261.02	1261.28	1261.65	1262.18	1262.54	1262.79	1262.98
10.1	794	1260.64	1260.83	1261.03	1261.33	1261.73	1262.05	1262.33	1262.59
10.2	843	1260.57	1260.75	1260.96	1261.26	1261.64	1261.96	1262.25	1262.51
11	945	1260.51	1260.66	1260.84	1261.13	1261.51	1261.83	1262.12	1262.38
12	1050	1260.29	1260.49	1260.71	1261.02	1261.39	1261.72	1262.01	1262.27
13	1186	1260.17	1260.41	1260.64	1260.96	1261.31	1261.64	1261.94	1262.20
19	1227	1260.15	1260.38	1260.60	1260.91	1261.25	1261.59	1261.89	1262.16
20	1347	1260.03	1260.23	1260.43	1260.63	1260.90	1261.17	1261.43	1261.67
21	1422	1259.85	1259.99	1260.17	1260.40	1260.81	1261.15	1261.45	1261.72
22	1497	1259.58	1259.78	1260.01	1260.28	1260.69	1261.03	1261.32	1261.58
23	1547	1259.45	1259.68	1259.94	1260.23	1260.65	1260.99	1261.29	1261.55

Figure 4.4.1 Pre-cutoff (1973) Water Surface Profiles



4.5 MODELING OF IMMEDIATE POSTCUTOFF CONDITIONS (1974)

Dataset Construction

A third HEC-2 dataset was constructed to simulate the hydraulics for the SFSR Oxbow for the period immediately after the Cutoff channel had opened. As described in Chapter 3, evidence indicates that the breach continued to widen and deepen since the initial cutoff. Hence, it was necessary to adjust the Cutoff channel to account for the erosion and cutting that had occurred from the time of the cutoff to the time of the 1990 survey. The following adjustments were made to simulate the immediate postcutoff conditions:

(1) The HEC-2 dataset was setup for the other portions of the SFSR Oxbow and Cutoff. It was assumed that there were no immediate changes to the upstream and downstream portions of the river, so the precutoff cross sections were used. It was not known how quickly deposition occurred in the Oxbow channel, but an upper limit of 30% of existing deposition was established. Two versions of the Oxbow channel were used. The first version assumed no deposition in the Oxbow Channel and used the cross sections from the preexisting conditions dataset. The second version assumed the upper limit of 30% deposition. Oxbow cross sections reflecting the 30% deposition were constructed by proportionally filling in the preexisting condition cross sections 30% of the way to the deposition levels of the existing condition cross sections.

(2) Adjustment of the Cutoff channel required several steps. The widths of the channel were estimated from aerial and oblique photographs, but the degree of downcutting was unknown. First, the cross sections were adjusted to account for the narrower widths. The bank stations were moved in towards the thalweg and maintained at the same elevation.

(3) Estimating the elevation of the thalweg required an iterative split flow analysis. The limits of variation in thalweg elevation were known. The 1990 elevations established a lower limit on thalweg depths. The elevations of the top of banks was assumed to be the

upper limit. A photograph (Figure 2.3.1) taken September 16, 1974 allowed us to estimate the discharge through the breach to be 1.84 cms (65 cfs) and gaging records were used to compute the total discharge to be 3.77 cms (133 cfs) at that time. The flow split data was used to solve for the depth of the Cutoff channel. The cross sections were proportionally adjusted to create datasets for the upper and lower bounds of channel depth. HEC-2 was run and the flow split was computed for these limits. As expected, the results indicated that the channel depths were somewhere between the two bounds. If the channel was cut too deep, more flow entered the breach than was observed in the photograph. If the breach was cut too shallow, too much flow went into the Oxbow channel. By iteration, it was possible to determine the cutoff channel depths which produced the desired flow split.

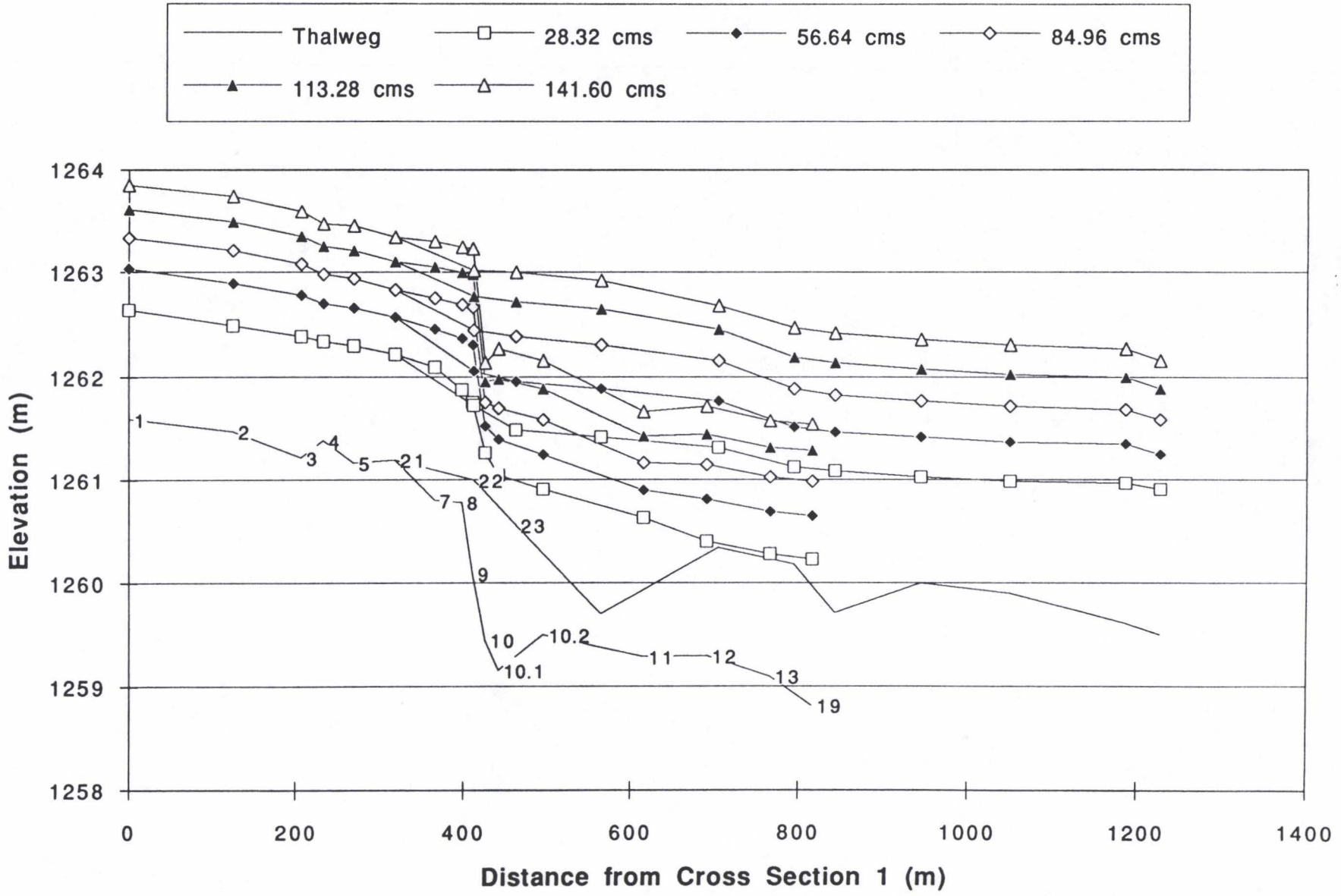
Rating curves for immediate postcutoff conditions

After the adjustments to the Cutoff channel were completed, two cases were run using HEC-2. The first case assumed no deposition in the Oxbow and the second case assumed that 30% of the present deposition in the oxbow was in place. Sensitivity analysis of the two cases indicated that there were minimal differences in the results (on the order of millimeters of water surface elevation). The effects of deposition could only be seen at extremely low flows. It was decided to use the case with no deposition for the final analysis. A series of runs were then made to develop rating curves for series of discharge values. Table 4.5.1 tabulates and Figure 4.5.1 displays the water surface profiles for various flows.

Table 4.5.1 Water surface profiles for immediate postcutoff conditions (1974).

Cross Section	River Station (m)	Water Surface Elevation (m) at Following Discharges							
		2.832 cms (100 cfs)	7.08 cms (250 cfs)	14.16 cms (500 cfs)	28.32 cms (1000 cfs)	56.64 cms (2000 cfs)	84.96 cms (3000 cfs)	113.28 cms (4000 cfs)	141.60 cms (5000 cfs)
Main Channel and Breach									
1	0	1262.11	1262.26	1262.41	1262.64	1263.03	1263.33	1263.61	1263.85
2	125	1261.97	1262.10	1262.23	1262.49	1262.89	1263.21	1263.49	1263.74
3	207	1261.81	1261.96	1262.12	1262.39	1262.78	1263.08	1263.35	1263.59
4	234	1261.75	1261.92	1262.08	1262.34	1262.70	1262.98	1263.25	1263.47
5	270	1261.69	1261.87	1262.04	1262.30	1262.66	1262.94	1263.21	1263.45
6	319	1261.61	1261.79	1261.97	1262.22	1262.57	1262.83	1263.10	1263.34
14	366	1261.53	1261.72	1261.90	1262.10	1262.46	1262.75	1263.05	1263.30
15	398	1261.35	1261.49	1261.63	1261.88	1262.37	1262.69	1263.00	1263.24
16	411	1260.88	1261.22	1261.44	1261.76	1262.31	1262.67	1262.98	1263.23
17	426	1260.44	1260.61	1260.94	1261.27	1261.53	1261.76	1261.96	1262.14
18	442	1260.21	1260.46	1260.70	1261.05	1261.40	1261.70	1261.98	1262.27
19	496	1260.15	1260.38	1260.60	1260.91	1261.25	1261.59	1261.89	1262.16
20	616	1260.03	1260.23	1260.43	1260.63	1260.90	1261.17	1261.43	1261.67
21	691	1259.85	1259.99	1260.17	1260.40	1260.81	1261.15	1261.45	1261.72
22	766	1259.58	1259.78	1260.01	1260.28	1260.69	1261.03	1261.32	1261.58
23	816	1259.45	1259.68	1259.94	1260.23	1260.65	1260.99	1261.29	1261.55
Oxbow Channel									
6	319	1261.61	1261.79	1261.97	1262.22	1262.57	1262.83	1263.10	1263.34
7	412	1261.23	1261.36	1261.56	1261.73	1262.06	1262.45	1262.77	1263.02
8	463	1260.92	1261.04	1261.23	1261.49	1261.96	1262.39	1262.72	1263.00
9	565	1260.62	1260.84	1261.11	1261.42	1261.89	1262.31	1262.65	1262.92
10	705	1260.59	1260.78	1261.03	1261.32	1261.77	1262.16	1262.46	1262.68
10.1	794	1260.46	1260.63	1260.86	1261.13	1261.52	1261.89	1262.19	1262.47
10.2	843	1260.36	1260.56	1260.80	1261.09	1261.47	1261.83	1262.14	1262.42
11	945	1260.34	1260.51	1260.74	1261.03	1261.42	1261.77	1262.08	1262.36
12	1050	1260.20	1260.43	1260.66	1260.99	1261.37	1261.72	1262.03	1262.31
13	1186	1260.16	1260.41	1260.64	1260.97	1261.35	1261.69	1262.00	1262.27
19	1227	1260.15	1260.38	1260.60	1260.91	1261.25	1261.59	1261.89	1262.16

Figure 4.5.1 Immediate Post-cutoff (1974) Water Surface Profiles



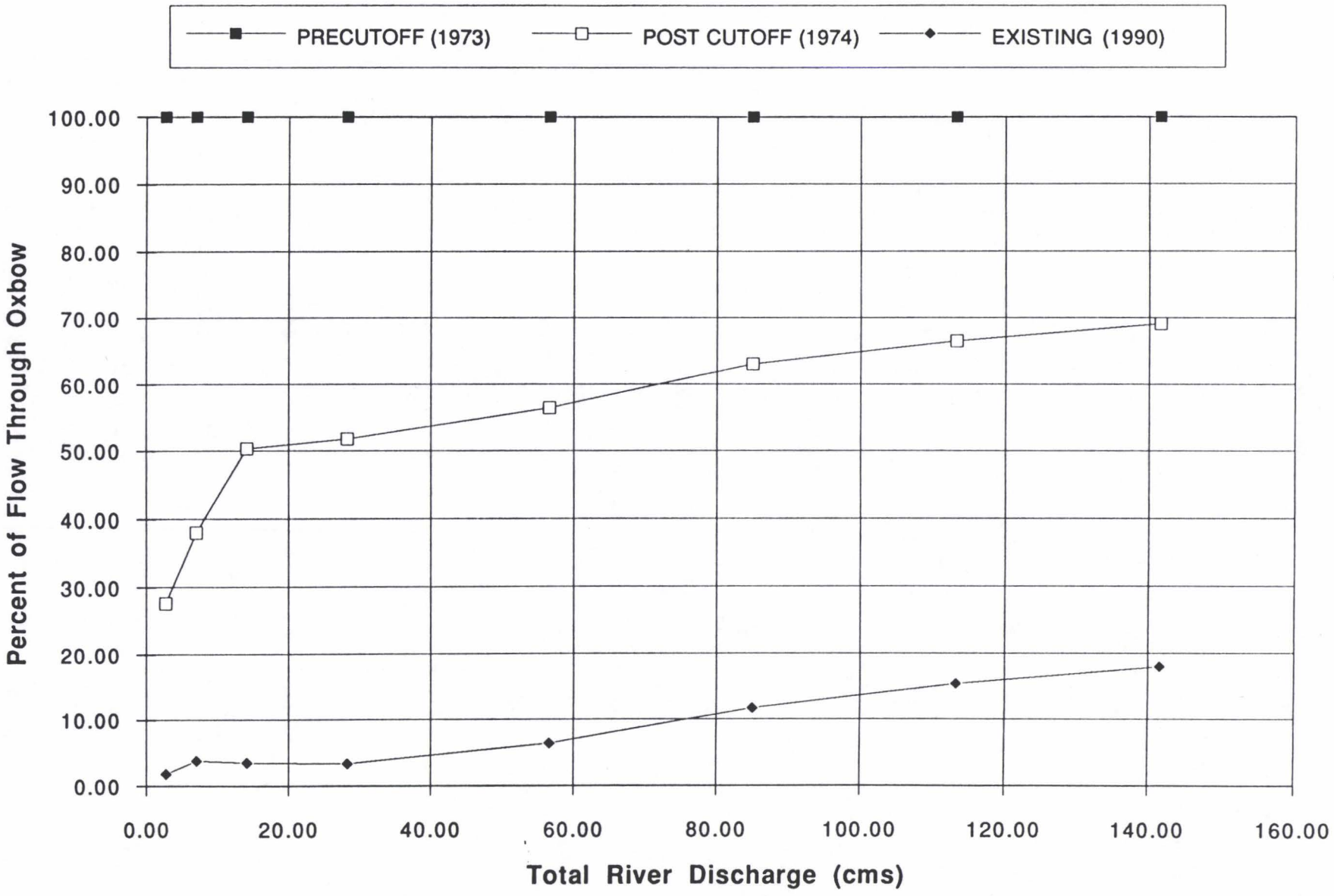
4.6 COMPARISION OF SPLIT FLOW

One of the most interesting aspects of the HEC-2 analysis are the results of the split flow computations. The flow splits between the oxbow and breach for the three scenarios are tabulated in Table 4.6.1. The percentage flow entering the oxbow is illustrated in Figure 4.6.1. It is interesting to note the growth in the volume of flow captured by the cutoff channel. As deposition in the oxbow increases and the breach enlarges, it is likely that the breach will capture all of the river flow except for extreme events.

Table 4.6.1 Flow split in oxbow and breach.

Total River Discharge (cms)	Oxbow Discharge (cms)			Percent of Total River Discharge in Oxbow		
	Precutoff (1973)	Post Cutoff (1974)	Existing (1990)	Precutoff (1973)	Post Cutoff (1974)	Existing (1990)
2.83	2.83	0.78	0.05	100.00	27.61	1.87
7.08	7.08	2.70	0.27	100.00	38.14	3.81
14.16	14.16	7.13	0.50	100.00	50.35	3.53
28.32	28.32	14.67	0.95	100.00	51.80	3.35
56.64	56.64	31.99	3.63	100.00	56.48	6.41
84.96	84.96	53.63	9.96	100.00	63.12	11.72
113.28	113.28	75.38	17.48	100.00	66.54	15.43
141.60	141.60	97.90	25.45	100.00	69.14	17.97

Figure 4.6.1 Flow Split for Modeled Discharges



5. ANALYSIS AND SUMMARY OF CHANNEL CHANGES

The purpose of this chapter is to interpret the channel changes that have occurred over the past 17 years in terms of the channel hydraulics developed in Chapter 4. We then use this information to discuss the future channel changes that might be anticipated. Estimates of future channel change can never be exact; there must always be a probabilistic component. For example, we can estimate likely channel changes given future flows we might reasonably expect, but there is always some probability of a catastrophic flood.

In estimating future channel changes from past river behavior, two questions must be asked concerning the observations available. The first is whether the magnitude and frequency of recorded discharges are representative of the future flows. This effort is based primarily on the 24 years of USGS discharge records available for the SFSR at the Krassel gage. The second question is whether the channel response to past flows is representative and likely to continue, or a result of relatively unique conditions prevailing only at the time. Of leading importance here is the overall response of the SFSR to the general decrease in sediment supply to the river following the 1965 moratorium on logging and road construction and the implementation of sediment control practices in the watershed.

5.1 FLOOD HYDROLOGY

The flow which caused the meander cutoff was the largest discharge of record for the 24 years of record on the SFSR. Figure 5.1.1 is a hydrograph showing all flows above 28 m^3/sec (1000 cfs) at the Krassel gage, the gaging station with the longest record on the SFSR. Based upon May, 1991 field observations, 28 cms is safely below any flows that are effective in transporting gravel.

There are two USGS gaging stations on the SFSR in the vicinity of the oxbow reach. Table 5.1.1 shows the locations and characteristics of these two gaging stations.

Figure 5.1.1 Discharges greater than 28 cms (1000 cfs) at Krassel, 1974-1990

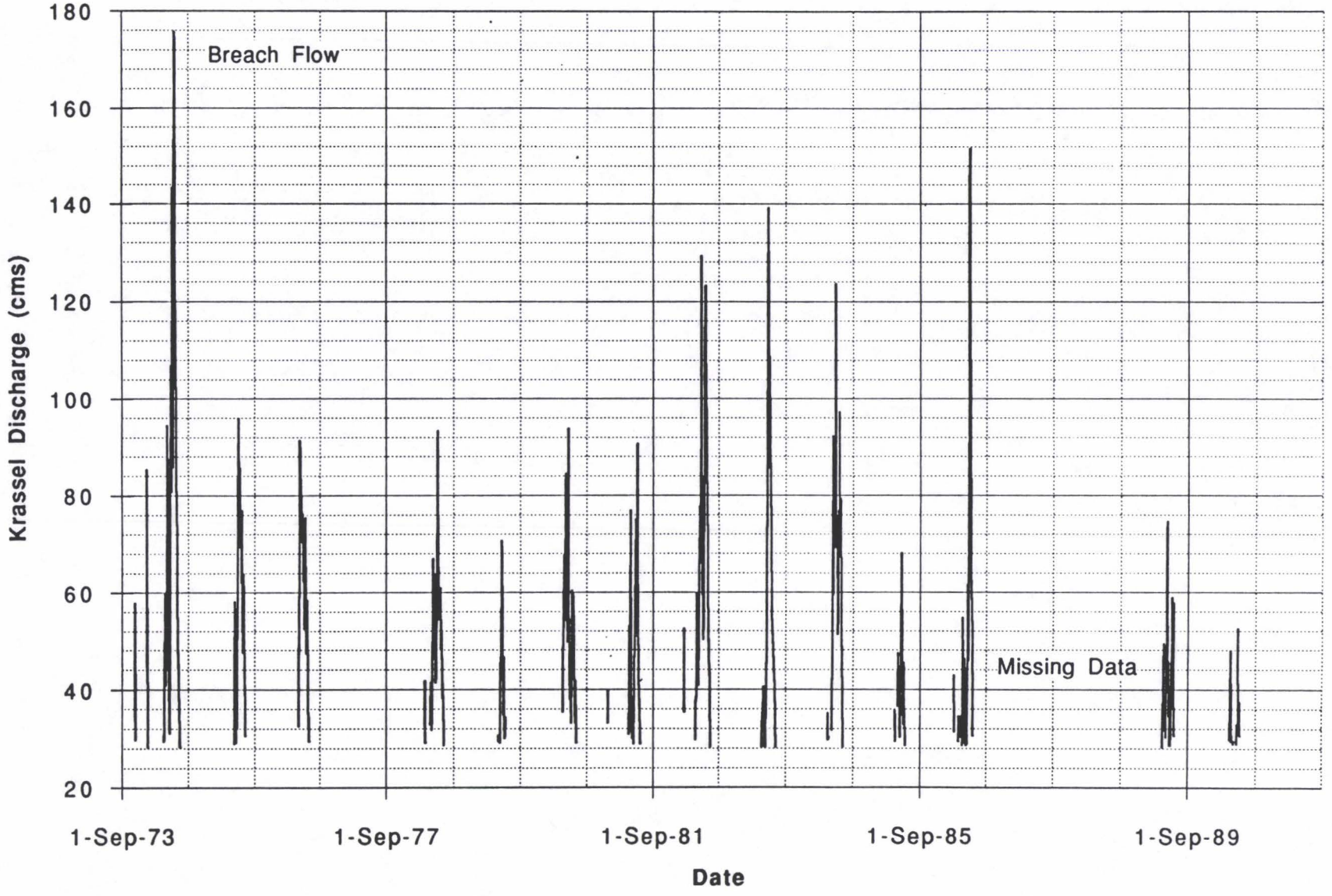


Table 5.1.1 SFSR Gaging Stations

Gaging Station	Location	Drainage Area	Records Begin
Poverty Flats USGS No. 13310570	10 km upstream of oxbow reach	513 km^2	1989 WY
Krassel USGS No. 13310700	16 km downstream of oxbow reach	855 km^2	1967 WY

Because the period of record is so short for the Poverty Flats gage, any conclusions concerning flood hydrology on the SFSR must be drawn from the Krassel record. The flood that breached the oxbow had a peak discharge of 191 m^3/sec (6740 cfs) at Krassel, and an estimated recurrence interval of 41 years. Table 5.1.2 lists the maximum annual flows for the Krassel gaging station. All water years since 1967 are included except for 1987 and 1988 for which data were not published. The study reach discharge was computed by scaling the Krassel discharge to the oxbow reach using a ratio of drainage area. All return periods for this report were obtained from a flood frequency analysis done by the U.S. Geological Survey for the Krassel station using a Log-Pearson Type III distribution (U.S.W.R.C., 1981). This flood frequency analysis is in Appendix E.

Table 5.1.2 Maximum annual flows at Krassel, precutoff left justified, cutoff centered, and postcutoff right justified.

Rank	Water Year	Krassel Discharge (cms)	Study Reach Discharge (cms)	Return Period (years)
1	1974	190.9	138.9	41
2	1972	159.4	116.0	13
3	1986	151.5	110.2	10
4	1982	145.0	105.5	8
5	1971	143.6	104.5	7
6	1983	138.8	101.0	6
7	1970	133.7	97.2	5
8	1984	123.5	89.8	4
9	1967	108.7	79.1	2
10	1969	105.9	77.1	2
11	1975	101.7	74.0	2
12	1981	100.8	73.3	2
13	1980	100.5	73.1	2
14	1978	97.1	70.7	2
15	1976	96.9	70.5	2
16	1989	78.7	57.3	1
17	1979	74.2	54.0	1
18	1985	73.1	53.2	1
19	1973	69.7	50.7	1
20	1968	69.4	50.5	1
21	1990	52.4	38.1	1
22	1977	22.0	16.0	1

The flood hydrology since the cutoff has been characterized by two four-year runs of low peak floods ($Q < 100$ cms, 1976-1979, 1987-1990). At the same time, four of the eight largest floods in the 26 years have occurred in this period. These floods all exceeded 85 cms at the study reach, which is the flood we judge to be bankfull in the alluvial parts of the channel. These floods are presumed to be capable of producing significant, channel forming transport and should, therefore, have been capable of producing channel change in response to the cutoff. Although the proportion of years with small floods appears to be larger after the cutoff than before, we judge the four largest post cutoff floods to have been capable of producing a detectable channel response to the cutoff.

5.2 Channel response to changes in sediment load from watershed

Prior to 1965, excessive sediment loading from logging and mining activities had produced widespread deposition of sand in the channel of the SFSR (Seyedbagheri et al., 1987). In 1965, a moratorium on logging and road construction, together with the sediment control measures,

produced a dramatic decrease in sediment input to the river. Megahan and others (1980) have documented a general lowering of the river bed as high flows flushed the accumulated sediments downstream. Bed erosion observed in our study reach must be interpreted in terms of this general lowering in SFSR channel.

Most of the reduction in sediment loading appears to have occurred over the first five years after the moratorium (Megahan et al., 1980). Channel response will lag behind the decreased sediment loading, primarily as a function of the magnitude and duration of high discharges. It is likely that the general channel response to the decreased sediment input was nearly complete with the breach-opening 1974 flood, because six of the highest ten flows in the 26 year record occurred in the nine years between 1967 and 1974, including the two largest. Channel surveys beginning in 1966 demonstrate that a significant amount of bed lowering had occurred by 1974 (Megahan and others, 1980). It is not possible to definitively conclude that all bed degradation related to sediment input reduction was complete by the time of the cutoff, but it is likely that most of the reduction had occurred by 1977 and that the remaining bed lowering would be small (Kenworthy and Edwards, 1985).

5.3 ANALYSIS OF CHANNEL CHANGE

Erosion and deposition in a channel are controlled by the balance between sediment supply and the capacity of the river to transport sediment. If we assume that the upstream reach in the study area had adjusted to the water and sediment supply from upstream, any factor, such as the breach, that increases the bed shear stress and transport capacity of the reach will tip the established balance. Erosion results when the transport capacity is increased above the upstream sediment supply, erosion would result.

For two-dimensional, steady, uniform flow the bed shear stress (τ_o) may be expressed by

$$\tau_o = \gamma d S \qquad \text{(Eq. 5.3.1)}$$

where γ is the specific weight of water, d is the depth of the flow, and S is the bed slope. This expression for computing bed shear stress is commonly known as the depth-slope product. The

expression may be modified for steady, nonuniform flow by substituting the slope of the energy grade line (S_e) for the bed slope as shown in Equation 5.3.2.

$$\tau_o = \gamma d S_e \qquad \text{(Eq. 5.3.2)}$$

Equation 5.3.2 adds the effect of flow acceleration to the downslope component of the water weight in determining τ_o. Because the flow in natural rivers is three-dimensional, τ_o estimates based on Equation 5.3.2 are reasonably accurate for evaluating local flow and transport only for straight channels and in cross sections with little lateral topography (i.e. XS 1-6),and are much less accurate, and perhaps not even indicative, for cross sections with strong lateral topography (i.e. XS 17). We compute a local τ_o using the local depths (d) across a cross section. Because our hydraulic modeling was one-dimensional, we have only one energy slope (S_e) for a cross section.

We examined the hydraulics for a range of discharges using HEC-2 as described in Chapter 4. The two discharges that we have chosen to illustrate local bed shear stress changes are 85.0 cms (3000 cfs) and 141.6 cms (5000 cfs). A discharge of 85.0 cms is bankfull for the study reach of the SFSR and has an estimated recurrence interval of 3 years. Bankfull discharge should be capable of moving all of the sediment on the bed and effective in producing channel response to the breach. A discharge of 141.6 cms is slightly larger than the highest flow of record and has a recurrence interval of 50 years. Although a discharge of 85.0 cms can transport considerably less sediment than one of 141.6 cms, its much higher frequency tends to make it move effective in producing the channel size and shape that is typically observed.

Figure 5.3.1 shows the HEC-2 water surface profile for 85.0 cms. Figure 5.3.2 is the same plot for a discharge of 141.6 cms. For clarity, only the profiles through the breach are plotted for the two postcutoff cases (1974 & 1990). Both Figures 5.3.1 and 5.3.2 demonstrate that the shortened path through the breach produced an immediate drop in water level upstream of the breach and that this drop has persisted to the present.

Figure 5.3.1 Water Surface Profiles 85.0 cms (3000 cfs)

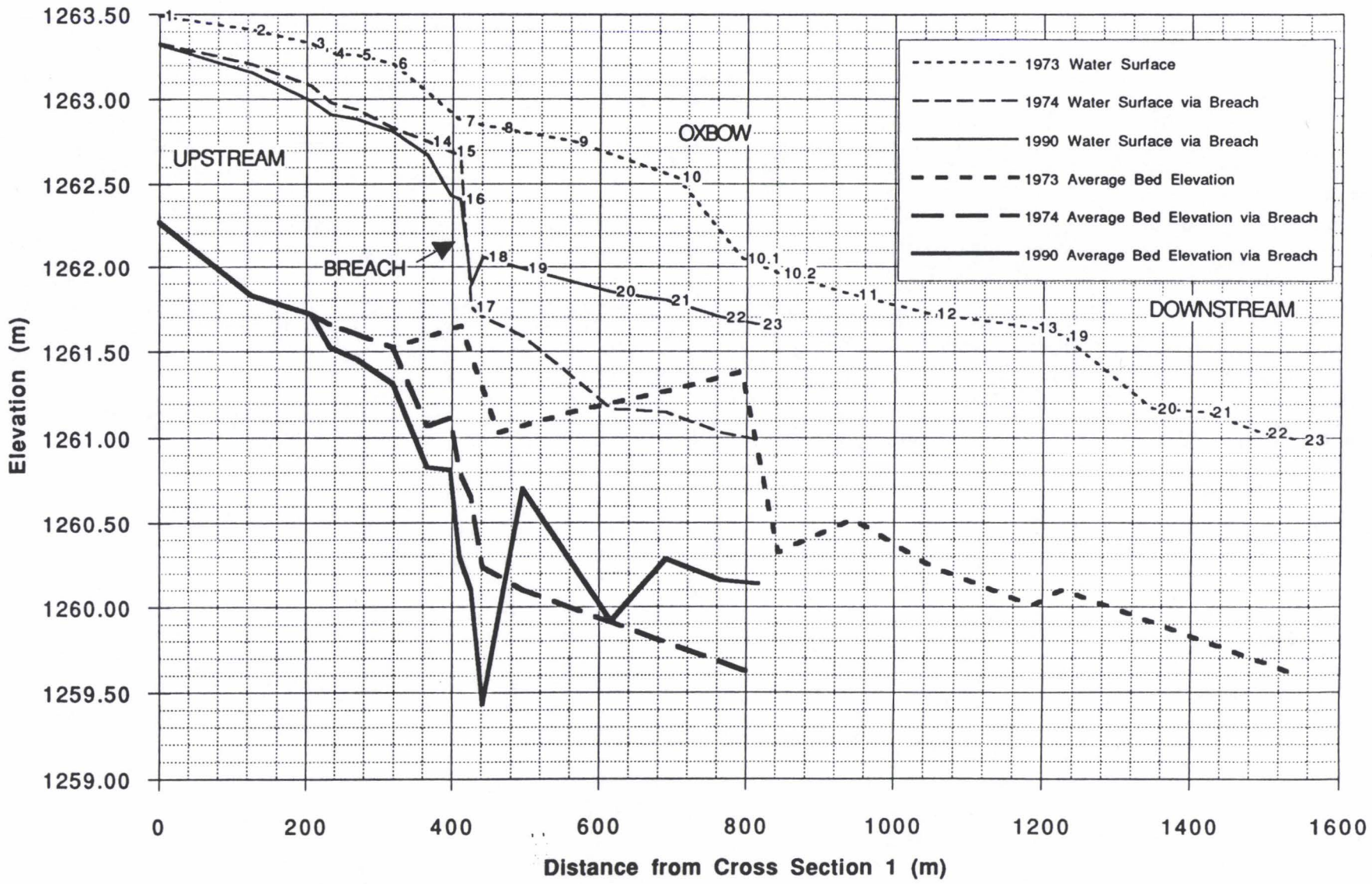
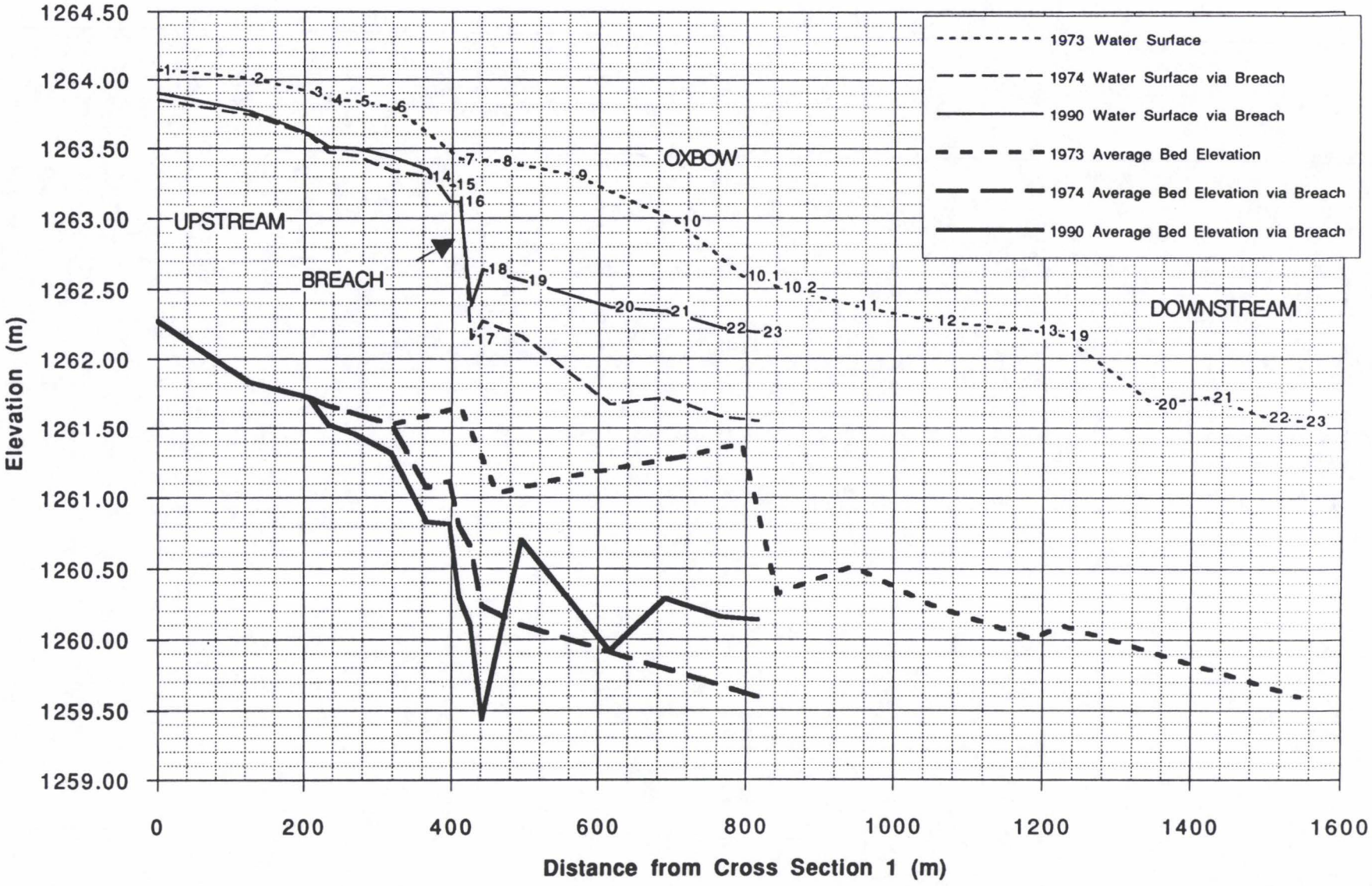


Figure 5.3.2 Water Surface Profiles 141.6 cms (5000 cfs)



Breach

Bed shear stresses through the breach are quite high as a result of the steep slope of the energy grade line. Figure 5.3.3 is a plot of the energy grade lines through the breach for immediate postcutoff and present conditions. The profiles begin at cross section 6, just upstream of the oxbow/breach split and terminate at cross section 18. Profiles are for total river discharges of 85.0 and 141.6 cms. Because the flow is divided between the oxbow and the breach, the flows through the breach are reduced (Table 5.3.1). The proportion of flow captured by the breach has more than doubled since 1974, to more than 80 percent.

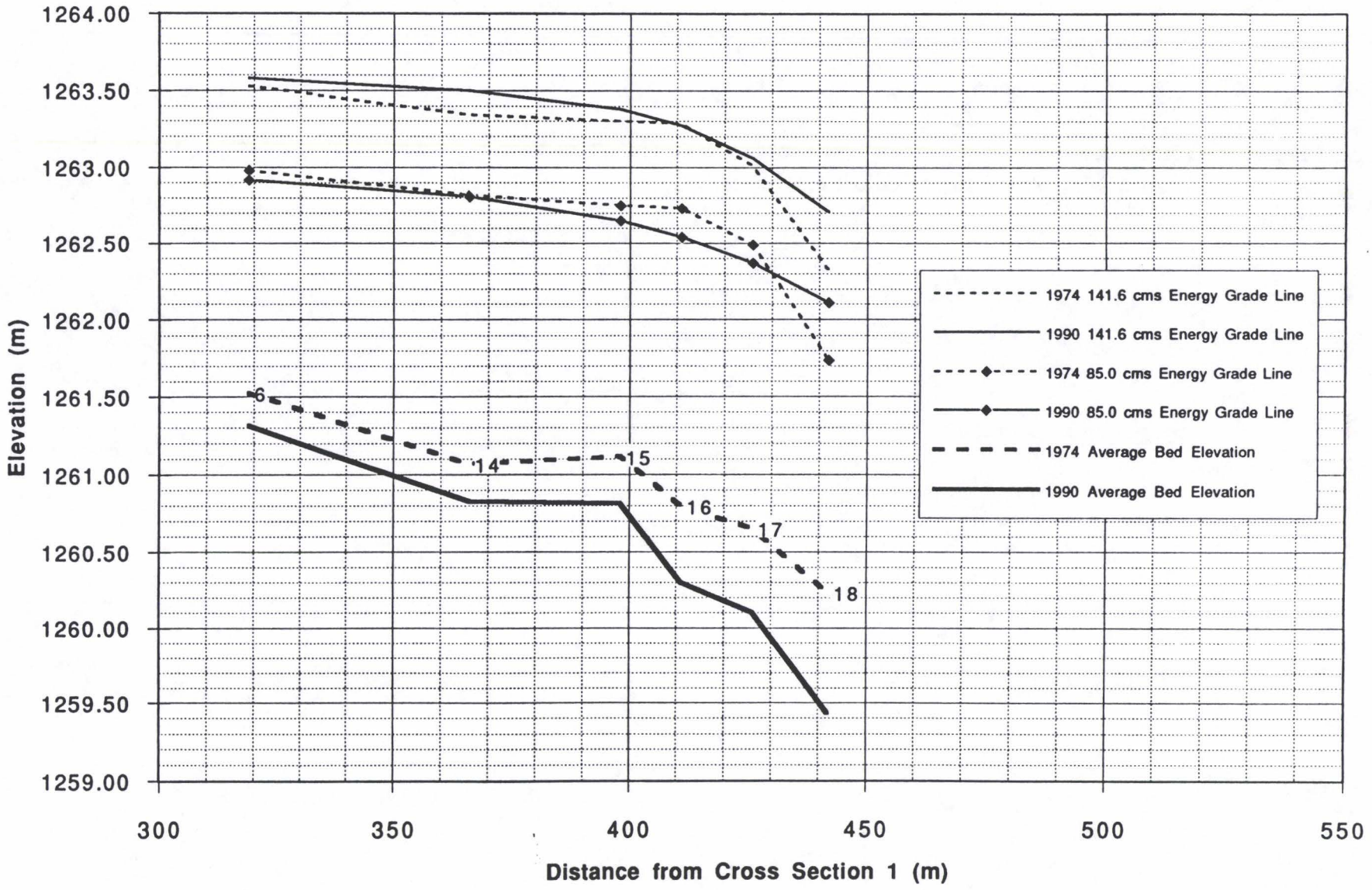
Table 5.3.1 Breach flows 85.0 and 141.6 cms total channel discharges.

	1974		1990	
Total River Discharge (cms)	85.0	141.6	85.0	141.6
Breach Discharge (cms)	31.3	43.7	75.0	116.2
% of Flow in Breach	37	31	88	82

Figures 5.3.4 (85.0 cms) and 5.3.5 (141.6 cms) are plots of the bed shear stress distributed across the channel for cross section 17. Bed shear stress (τ_o) was calculated using Equation 5.3.2. The slope of the energy grade line (S_e) for cross section 17 was computed by averaging the slope between sections 16 and 17 (upstream), and 17 and 18 (downstream). The 1990 cross sections are wider and deeper than the 1974 cross sections due to breach enlargement.

At 85.0 cms, the maximum bed shear stresses for the immediate postcutoff case (1974) are nearly double those at present (1990), although both are extremely high. Maximum computed τ_o for the 1974 case is 712 Pa, for 1990 it is 406 Pa. To place these values of τ_o in context, a τ_o of 500 Pa would correspond to the critical τ_o for particles 7 m in diameter using a Shields curve (Vanoni, 1977). These high values of τ_o are a result of the steep energy grade line through the breach. At 85.0 cms, the slope of the energy grade line through the breach has a maximum of nearly 5% for the immediate postcutoff channel (1974) configuration and a maximum of nearly 2% for the present (1990).

Figure 5.3.3 Breach Energy Grade Line



At 141.6 cms, the maximum τ_o occurs for the present conditions (1990), rather than with the 1974 immediate postcutoff channel configuration. Maximum computed τ_o for the 1974 case is 508 Pa, for 1990 it is 613 Pa. These bed shear stresses are of the same order of magnitude as the stresses at 85.0 cms. Again, the steep energy grade line is responsible for the high values of τ_o. The maximum energy slope at 141.6 cms has become gentler since 1975, from just over 4% immediately after the cutoff to just over 2% at present. The 1990 energy grade lines are less steep than the 1974 energy grade lines because the transition through the breach is a smoother one. The 1990 breach is wider and deeper and the downstream sub-reach bed elevation is higher due to deposition.

The sediment transport through the breach is almost exclusively a function of the sediment supply rather than the hydraulics. The scoured bedrock channel bed through the breach is the best evidence that transport is supply limited through the breach. Whatever sediment is provided by the upstream sub-reach is efficiently transported through the breach.

Upstream

Figure 5.3.6 plots the energy grade lines for the upstream sub-reach for 85.0 and 141.6 cms. Prior to the cutoff the slopes are roughly 0.1 % at both discharges. The postcutoff slopes are between 0.15 and 0.2 %. At the same time, water surface elevation has decreased following the cutoff, due to the drawdown effect of flow through the short steep breach. Because the increase in energy grade line slope is proportionally larger than the postcutoff decrease in flow depth, the postcutoff flows produce a larger bed shear stress in this reach.

Two cross sections (2 & 5) in the upstream sub-reach are used to demonstrate the distribution of τ_o. Cross section 2 was selected because it is the section for which we have the most historical data and because it is the location of the spawning gravels that could be potentially eroded. Cross section 5 was selected because it is near the downstream end of the upstream sub-reach. Cross section 6 is not used because it is the section where the flow splits between the oxbow and the breach and the hydraulics are more complex.

Figure 5.3.4 Cross Section 17 Bed Shear Stress at 85.0 cms (3000 cfs)

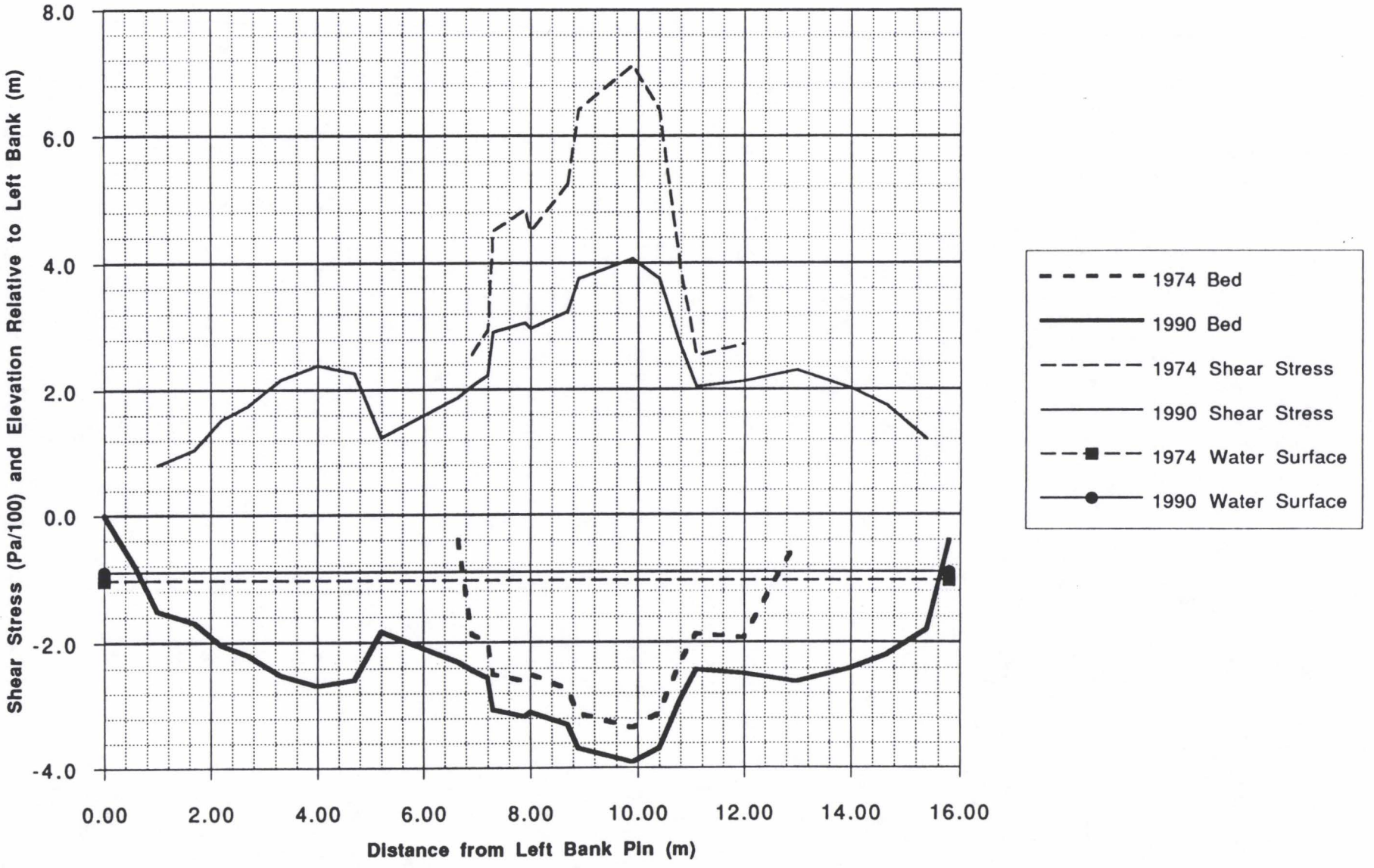


Figure 5.3.5 Cross Section 17 Bed Shear Stress at 141.6 cms (5000 cfs)

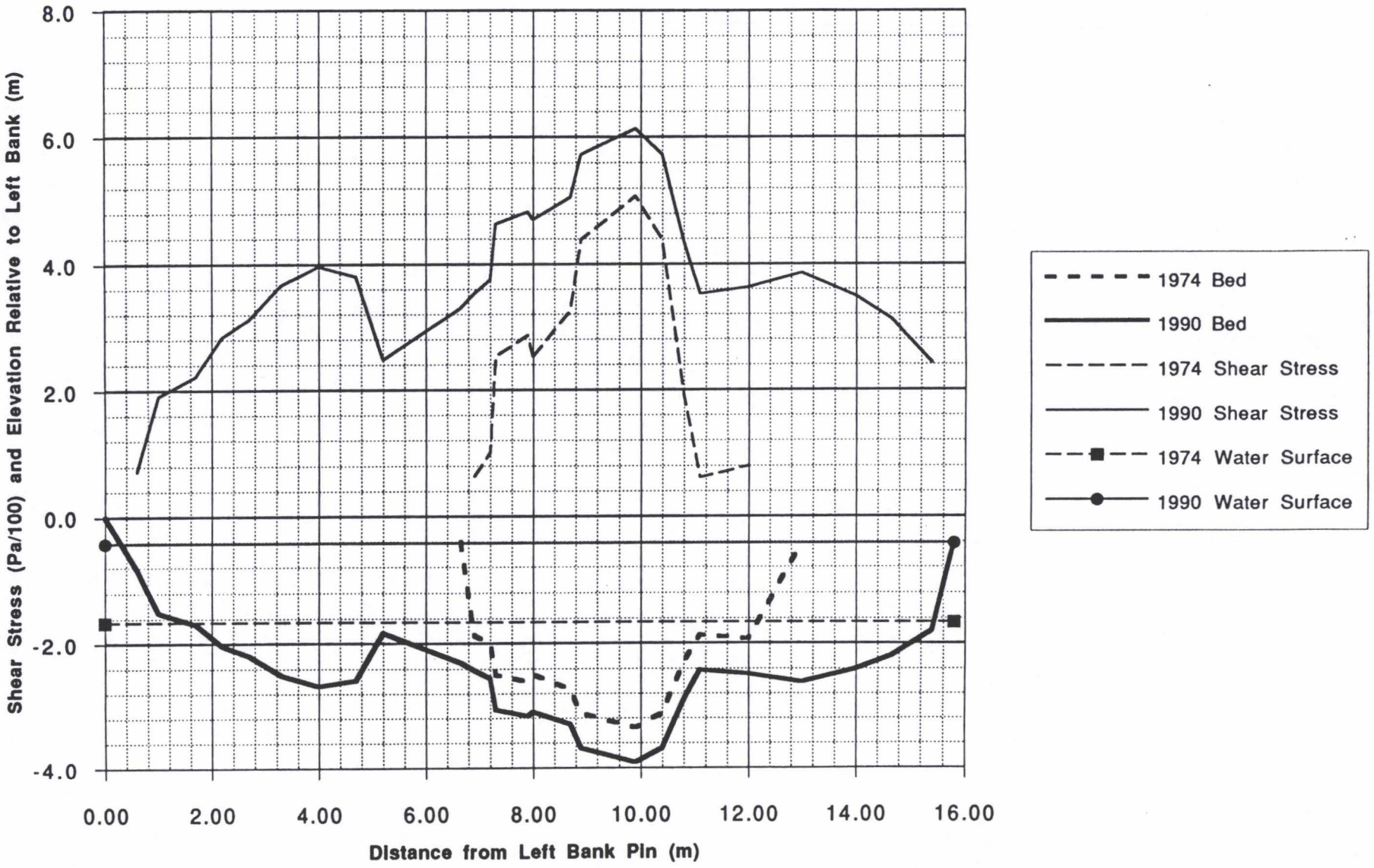


Figure 5.3.7 shows the distribution of τ_o across cross section 2 at 85.0 cms, and Figure 5.3.8 is an equivalent plot for 141.6 cms. The bed of cross section 2 is very regular with a slightly deeper (~20 cm) thalweg on the left side of the channel; the same cross section geometry was used for all three time scenarios. At 85.0 cms, τ_o across most of the bed was on the order of 15 Pa before the cutoff, 20 Pa immediately after the cutoff, and 23 Pa at present. This represents an increase in τ_o of roughly 30% immediately after the cutoff, and a further increase to 150 % of precutoff values today. The continued increase in τ_o following the cutoff is primarily due to our assumption that the bed has scoured 15 to 20 cm at cross sections 4 through 6, just downstream of cross section 2. At 141.6 cms, τ_o across most of the bed was on the order of 20 Pa before the cutoff, 30 Pa immediately after the cutoff, and 31 Pa at present. Bed shear stresses are slightly higher in the thalweg at all discharges.

Figures 5.3.9 and 5.3.10 show the distribution of τ_o at cross section 5 at 85.0 cms and 141.6 cms. Two bed topographies are plotted: our estimate of the pre and immediate postcutoff bed is shown with a dashed line, and the present topography, 15 cm lower, with a solid line. Cross section 5 has more lateral topography than section 2, but it is still relatively uncomplicated. At 85.0 cms, τ_o at cross section 5 increased 75 % with the cutoff and has decreased slightly in the following years to a value 50 % greater than the precutoff values. A similar result occurs at 141.6 cms, with τ_o values decreasing from 163 to 141 % of precutoff values from 1975 to 1990. The most striking difference between cross sections 2 and 5 is that τ_o has decreased at cross section 5 from the immediate postcutoff time to the present. The decrease in τ_o with time at cross section 5 is due to the corresponding drop in bed level used in the hydraulic modeling (Figure 5.3.6). Although not shown here, this temporal decrease in τ_o at cross section 5 does not occur at discharges much smaller than 85.0 cms.

Figure 5.3.6 Upstream Sub-Reach Energy Grade Line

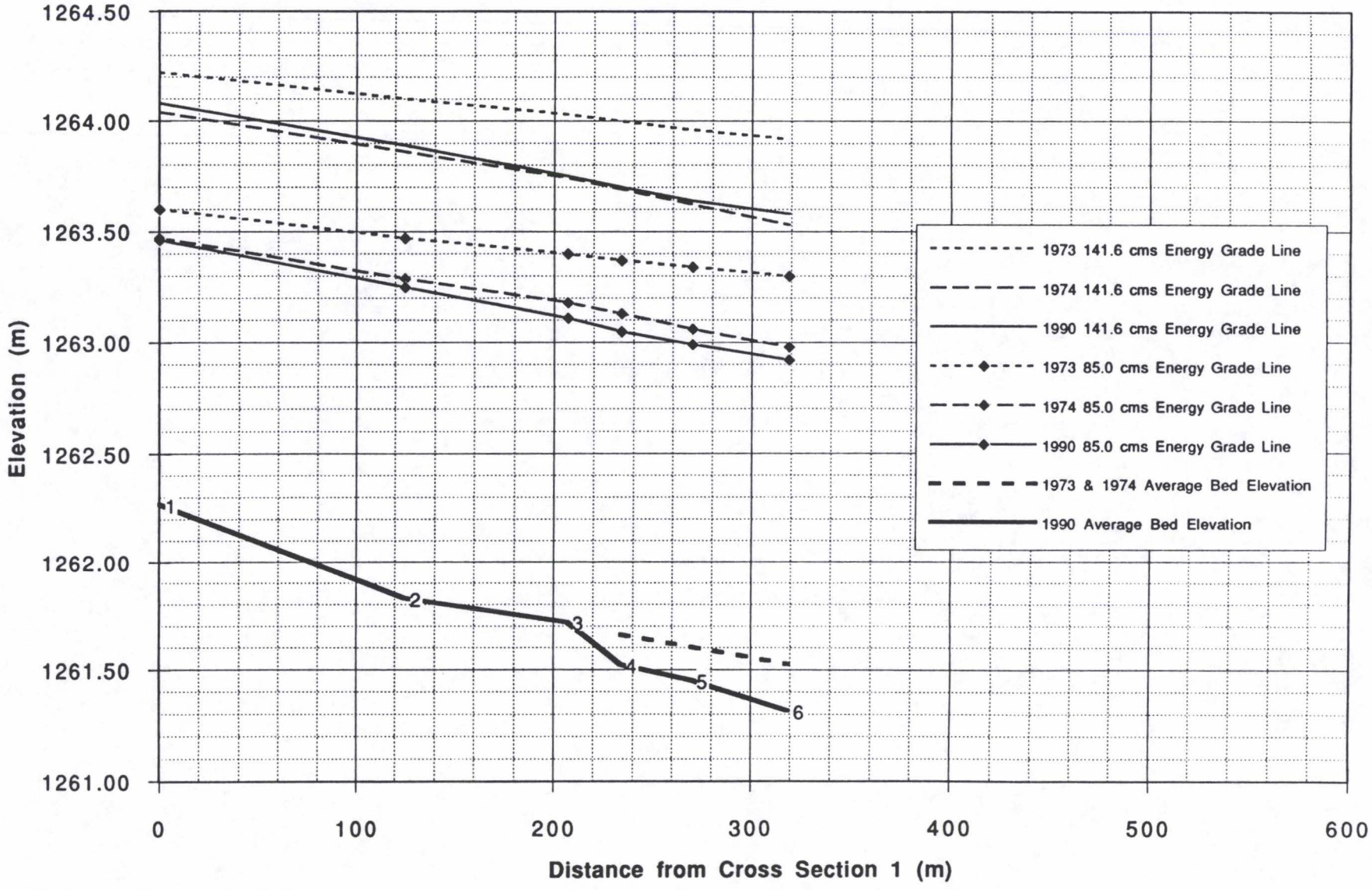


Figure 5.3.7 Cross Section 2 Bed Shear Stress at 85.0 cms (3000 cfs)

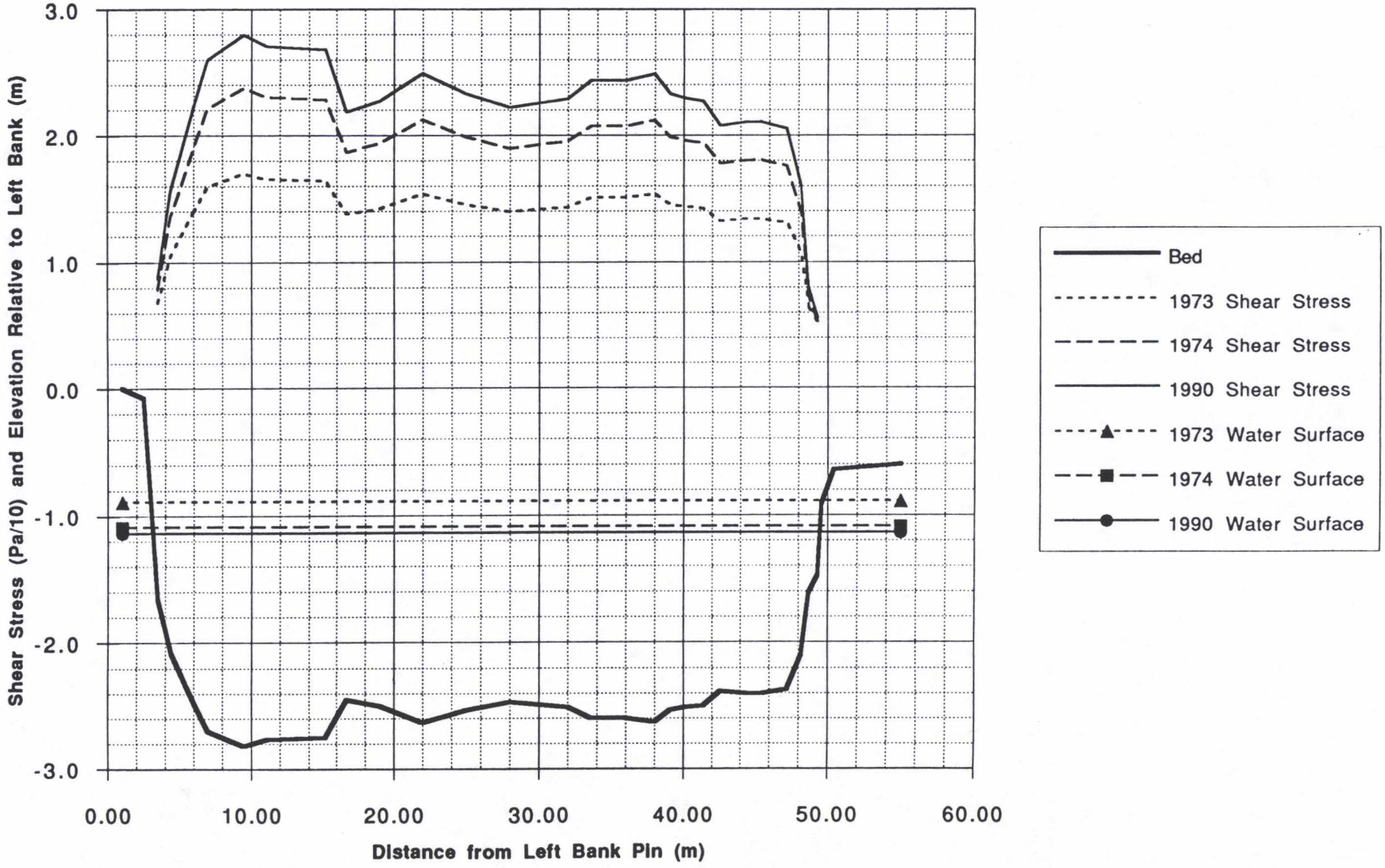


Figure 5.3.8 Cross Section 2 Bed Shear Stress at 141.6 cms (5000 cfs)

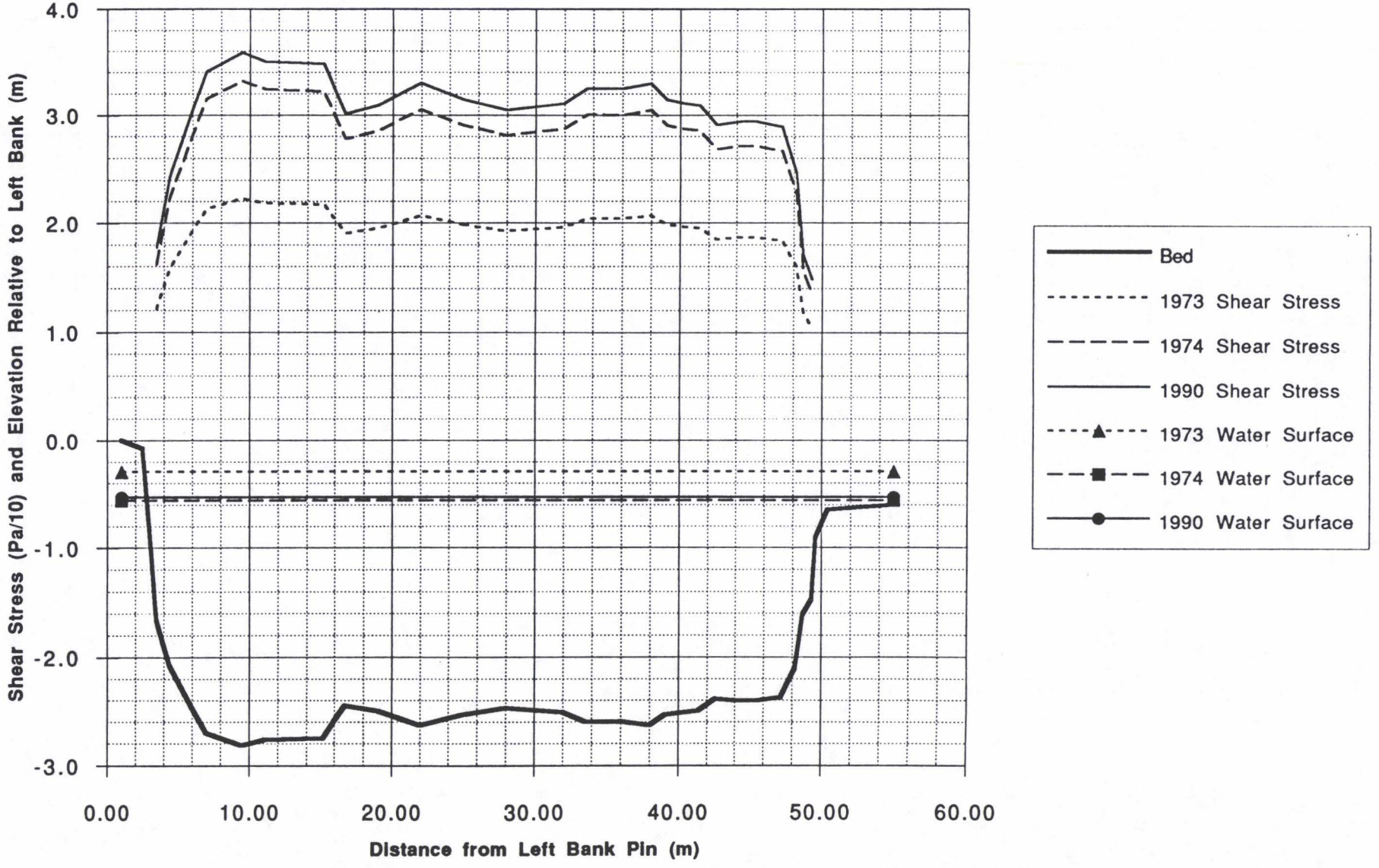


Figure 5.3.9 Cross Section 5 Bed Shear Stress at 85.0 cms (3000 cfs)

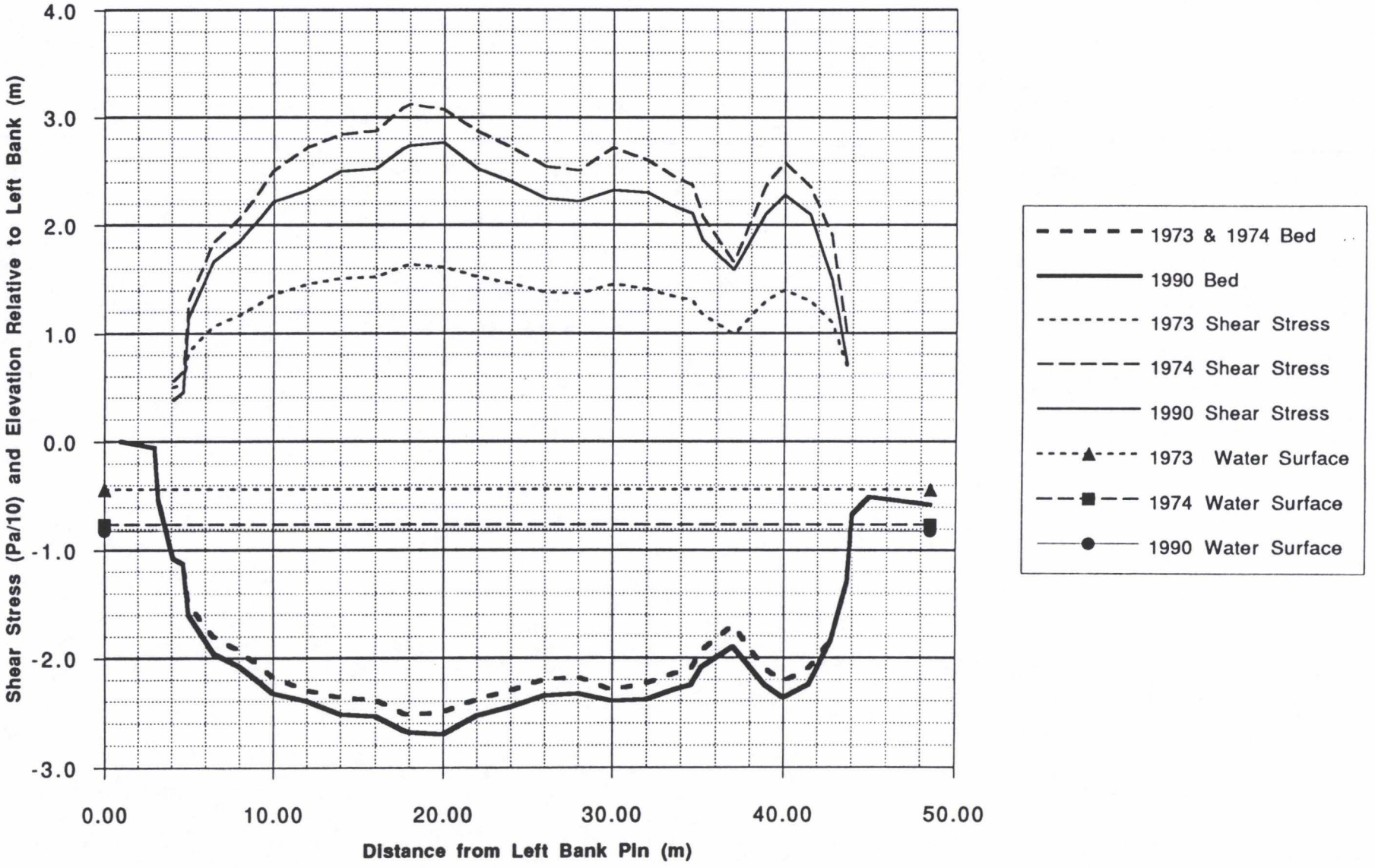


Figure 5.3.10 Cross Section 5 Bed Shear Stress at 141.6 cms (5000 cfs)

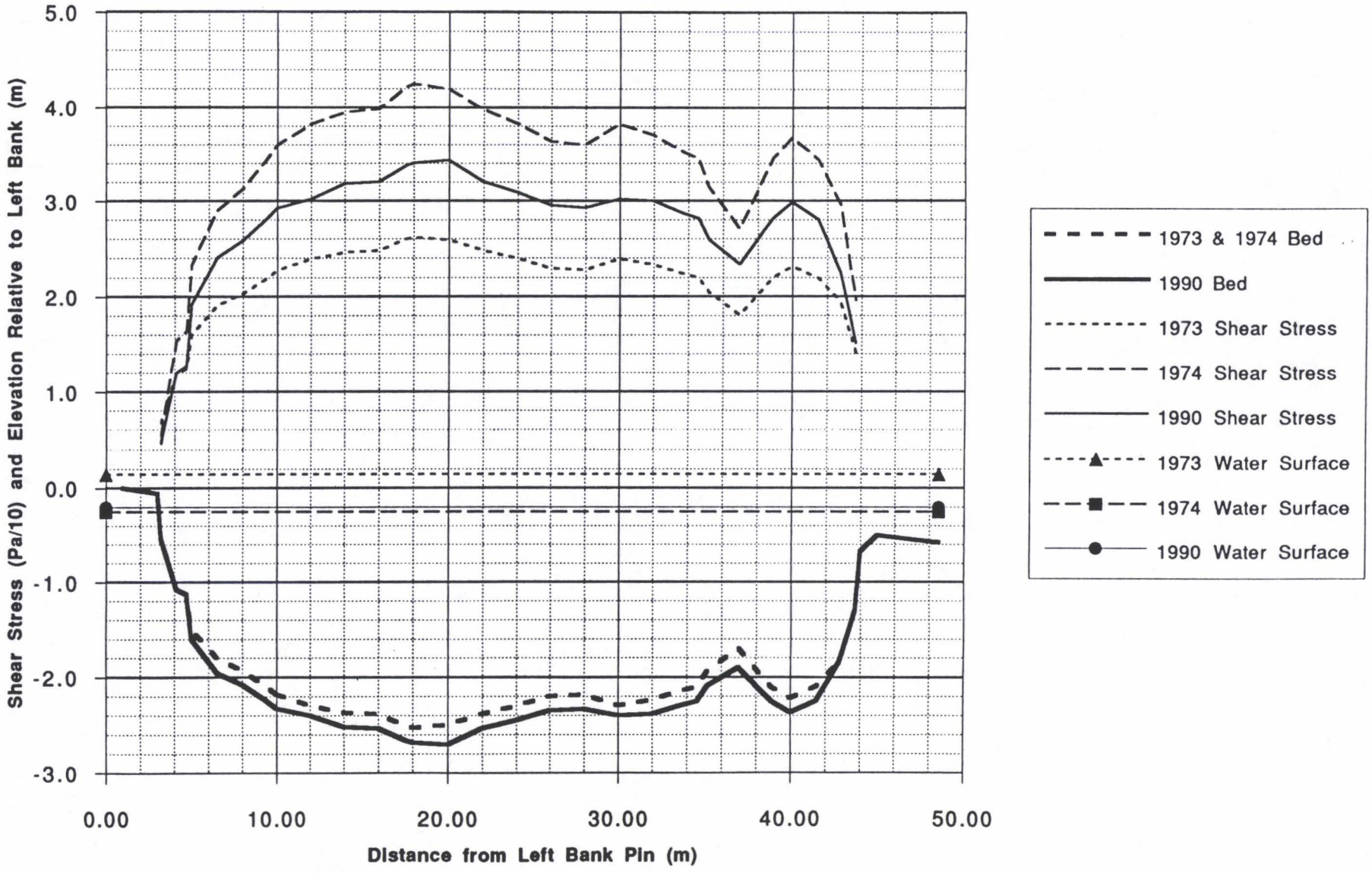


Table 5.3.2 Bed Shear Stress, Cross Sections 2 and 5.

	Bed Shear Stress Across Most of Channel (Pa) for Specified Location and Scenario								
	Precutoff (1973)			Immediate Postcutoff (1974)			Present (1990)		
Discharge	XS 2	XS 5	Diff.	XS 2	XS 5	Diff.	XS 2	XS 5	Diff.
85.0 cms	15	15	0	20	26	+3	23	23	0
141.6 cms	20	22	+2	30	36	+6	31	31	0

Prior to the cutoff, the average τ_o at bankfull discharge between cross sections 2 and 5 were approximately the same. Immediately after the cutoff τ_o increased at both cross sections although the increase is greater at cross section 5 because the energy grade line was steeper nearer the breach. Under present conditions, τ_o values are virtually the same at cross sections 2 and 5, and these values are 40 to 55 % higher than precutoff values.

The precutoff bankfull discharge of 85 cms (3000 cfs) provides a useful reference for investigating the change in bed shear stress between the pre and postcutoff cases. This is the discharge to which we assume the channel has adjusted and, therefore, must be capable of transporting the sediment load delivered to it from upstream. As we have demonstrated above, the steeper postcutoff flows produce a greater bed shear stress for the same discharge. Similarly, it takes a smaller discharge to produce the same shear stress. One way of documenting the breach impact is to calculate the smaller discharge, and therefore, the more frequent occurrence of bed shear stress of a given level.

We have calculated the average τ_o at bankfull discharge for cross sections 2 through 5 for precutoff conditions using Equation 5.3.2 and the average flow depth. Postcutoff (1974 & 1990) discharges that produce the same average τ_o are shown in Table 5.3.3. The "equivalent " discharge is roughly 60% of the precutoff bankfull discharge in 1974 and 40% of the precutoff discharge in 1990. These smaller discharges occur more frequently. Table 5.3.4 lists the number of days in the period 1974 to 1990 that the discharge producing precutoff bankfull bed shear stresses was equaled or exceeded. On average, the duration of flows producing precutoff bankfull

τ_o increased by a factor of 6 immediately after the cutoff (1990) and by a factor of 14 to the present (1990).

Table 5.3.3 Discharges producing precutoff bankfull average τ_o.

	Discharge (cms)			
	XS 2	XS 3	XS 4	XS 5
Precutoff (1973)	85 cms	85 cms	85 cms	85 cms
Postcutoff (1974)	58 cms	59 cms	50 cms	40 cms
Present (1990)	37 cms	33 cms	32 cms	36 cms

Table 5.3.4 Occurrence of discharges producing precutoff bankfull τ_o.

	Days above "equivalent" discharge, 1974 - 1990			
	XS 2	XS 3	XS 4	XS 5
Precutoff (1973)	34	34	34	34
Postcutoff (1974)	130	125	222	389
Present (1990)	445	527	573	472

Because τ_o has increased in the upstream sub-reach and because we have no evidence to suggest that sediment supply has increased, the breach has clearly increased the potential for erosion in the upstream reach. This evidence must be compared with our observations of erosion in this reach. Repeated surveys allow us to clearly demonstrate that little erosion has occurred at cross section 2. In addition, aerial photographs provide strong evidence that little bank erosion and channel widening has occurred. Downstream, we postulate 15 cm to 20 cm of bed erosion based on the deviation of today's bed elevation from our estimate of the precutoff bed elevation.

Some further evidence of downcutting in the downstream portion of this reach is provided by the fact that the bed is somewhat coarser at cross section 5 than at cross section 2. The median grain size at cross section 5 is 74 mm, while that at cross-section 2 is 43 mm, based on visual estimates of the median size of the bed sediment made during surveying. In a bed of mixed-size sediments, downcutting can produce bed armoring, as finer sizes are selectively removed during the scouring process. If downcutting occurred in response to the breach, the magnitude of downcutting and armoring should be greater at cross section 5, which is closer to the breach and

should decrease as one moves upstream. A downcutting of 20 cm at cross section 5 could produce the larger grain size observed there relative to cross section 2, although this can only be hypothesized because we do not know the precutoff grain size at cross section 5. Bed armoring provides a self-limiting mechanism by which beds can limit the amount of bed scour that can occur.

An alternative explanation for the minimal postcutoff erosion is that the flows since the cutoff have not been particularly effective in producing bed erosion, regardless of the relative change in τ_o caused by the breach. Such an argument could be based on a cycle of bed aggradation and degradation (driven by a cycle of first increased, then decreased, sediment inputs to the channel) leading to an oversized channel upstream of the breach. If significant bed aggradation occurred in the upper reach in response to the heavy sediment loads prior to 1965, a widening of the shallower channel could be produced by bank erosion during floods. If this channel widening were followed by a period of bed degradation related to a decrease in sediment load following 1965, the remaining channel would be somewhat oversized relative to the discharges it is likely to experience, but little evidence of this would remain in the surveyed cross section. Hence, discharges of the past 17 years could have been less effective than expected in producing channel scour in response to the oxbow cutoff.

Although the two arguments presented above are different, they are complementary and do not change the general conclusions that can be drawn. We can demonstrate that the breach, as would be expected, has increased the potential for erosion of the gravels immediately upstream. The reasons why this increased erosion potential has not produced greater observed erosion in the past 17 years may be related to an armoring effect, or to the fact that the channel is somewhat oversized, or both.

We observe that four floods with roughly a five to ten year recurrence interval have not produced dramatic erosion since the cutoff. The relatively weak response of the bed to these floods does not allow us to conclude that the upstream gravels are not at risk; the hydraulic analysis clearly demonstrates the potential for erosion has been increased by the breach. Floods 20 cms

larger than those experienced in the last 17 years may be expected over a twenty-five year period. A nominal 50 year flood of 141 cms will produce bed shear stresses 35% larger than those produced by the bankfull 85 cms flood. We have no direct evidence of the impact of such floods on the upstream reach, but the potential for bed erosion of the spawning gravels clearly exists.

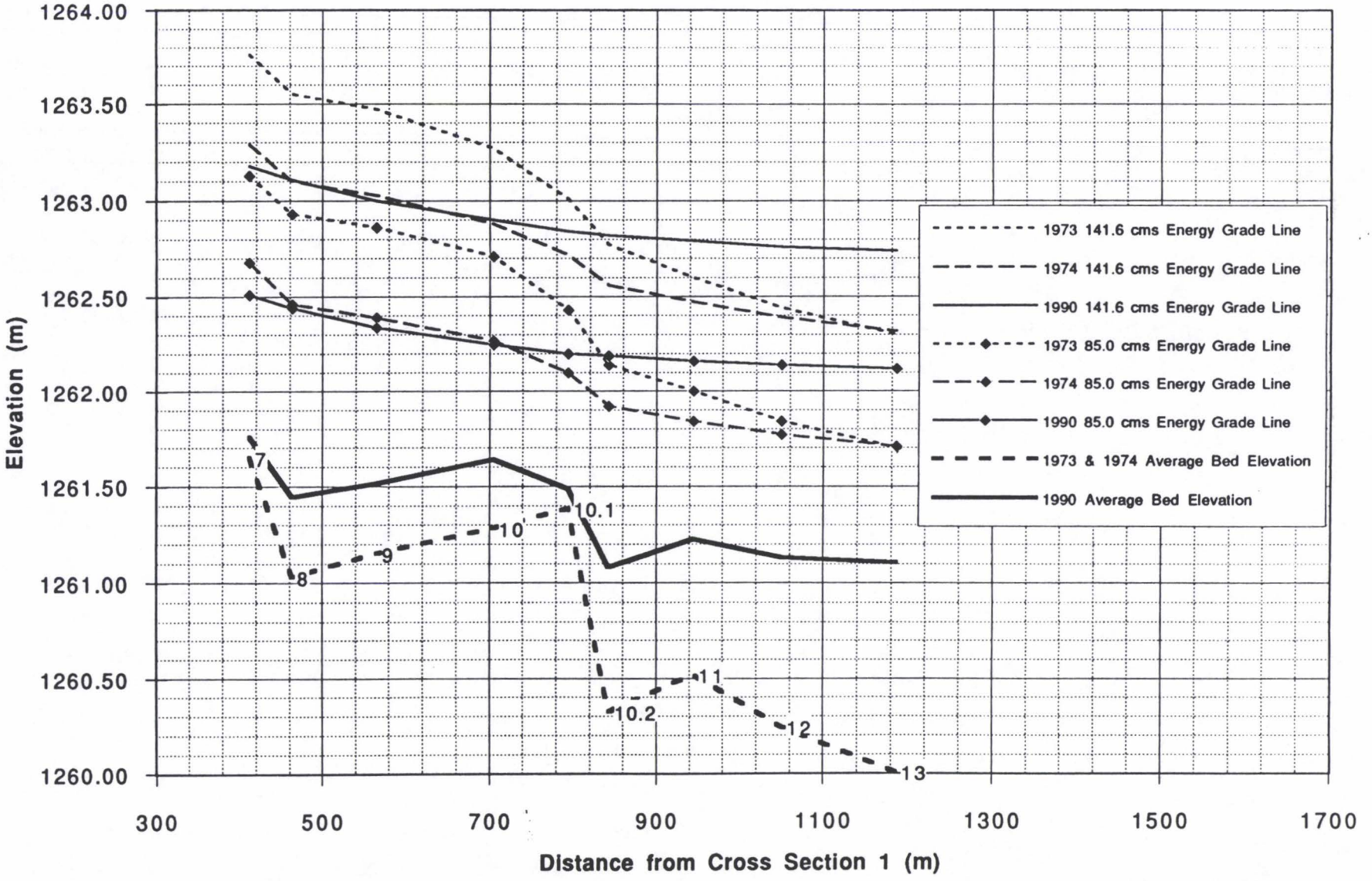
Because of the increased postcutoff bed shear stresses, moderate flows may be more effective in transporting the sand supply through the upstream reach. This may be beneficial in lessening the intrusion of fine sediments into spawning gravels. Such a cleansing trend in the oxbow spawning gravels has been observed since 1988 (Newberry, 1990).

One additional factor relates to the potential for preserving the gravels for spawning purposes. The Chinook and steelhead that use the gravels are on the order of 70 to 100 cm long (Chambers et al., 1955, and Orcutt et al., 1968, both as cited in Kondolf, 1988). Fish of this size are capable of spawning in gravels with a median size up to 70 mm (Kondolf, 1988). The coarse half of the gravels at the spawning site fall within the relatively narrow range of 55 mm to 120 mm. Substantial downcutting and armoring of these sediments could still leave a gravel with a median size in a range feasible for spawning. As a consequence, unless a flood is so extreme that it entirely removes the gravels from the reach, an erosive event greater than those experienced in the past 17 years may leave a coarsened gravel bed that falls within the size range for successful spawning.

Oxbow

Figure 5.3.11 is a plot of the energy grade line through the oxbow. These energy grade lines correspond to specific total river discharges (85.0 and 141.6 cms), but the postcutoff oxbow discharges are differing proportions of the total discharge due to the change in the oxbow/breach flow split over time. The break in slope in the energy grade lines in the vicinity of cross section 10.1 is the result of increased flow resistance of a debris fan which protrudes into the channel and has provided coarse bed material (boulders) to this area. The average slope of the energy grade line for precutoff conditions is 0.19 % for both discharges. Immediately after the cutoff (1974),

Figure 5.3.11 Oxbow Energy Grade Line



the slope was reduced to 0.13 % and further reduced to 0.06 % at present. This threefold reduction in slope, coupled with reduced flow depths, greatly reduced the bed shear stresses (and therefore, the sediment transport capacity) through the oxbow.

Figures 5.3.12 and 5.3.13 demonstrate the dramatic decrease in bed shear stress across cross section 12. Plots for other oxbow cross sections, although not shown here, show a similar decrease in bed shear stress of one order of magnitude. We expect that most sediment entering the oxbow at high flows will continue to deposit until all flows are entirely captured by the breach. The oxbow has been a net sediment sink since the cutoff, preferentially trapping the finer sediment. As a greater proportion of the flow has been captured by the breach and the oxbow has filled, it has become a less efficient trap.

Downstream

The changes in downstream hydraulics since the cutoff depend strongly upon our estimates of deposition and aggradation. The aggradation we have estimated has resulted in a gentler water surface slope, and hence a gentler energy grade line (Figure 5.3.14). If no deposition were to have occurred, the downstream hydraulics would be unchanged. Because the degree of deposition in this reach is poorly constrained, we draw no direct conclusions from the hydraulic output.

For many meander cutoffs, including the SFSR cutoff, the downstream sediment load can be initially coarser than the precutoff load because the oxbow preferentially traps finer sediments and the sediment transported through the breach is coarser due to the steeper slopes. The response of the downstream reach to a meander cutoff depends on both the quantity and the size of the sediment load, this is illustrated schematically in Figure 5.3.15. The abscissa is the postcutoff sediment load expressed as a proportion of the sediment load that would have been delivered to the downstream reach by the same discharge in the absence of the cutoff. We call this latter transport the 'normal' sediment load. The ordinate is the postcutoff sediment load grain size expressed as a proportion of the normal load grain size after the cutoff. A line divides the field between a depositional regime and an erosional one. For example, if the downstream reach were supplied less sediment of a smaller caliber, erosion would occur. The line slopes upward in the left because

Figure 5.3.12 Cross Section 12 Bed Shear Stress at 85.0 cms (3000 cfs)

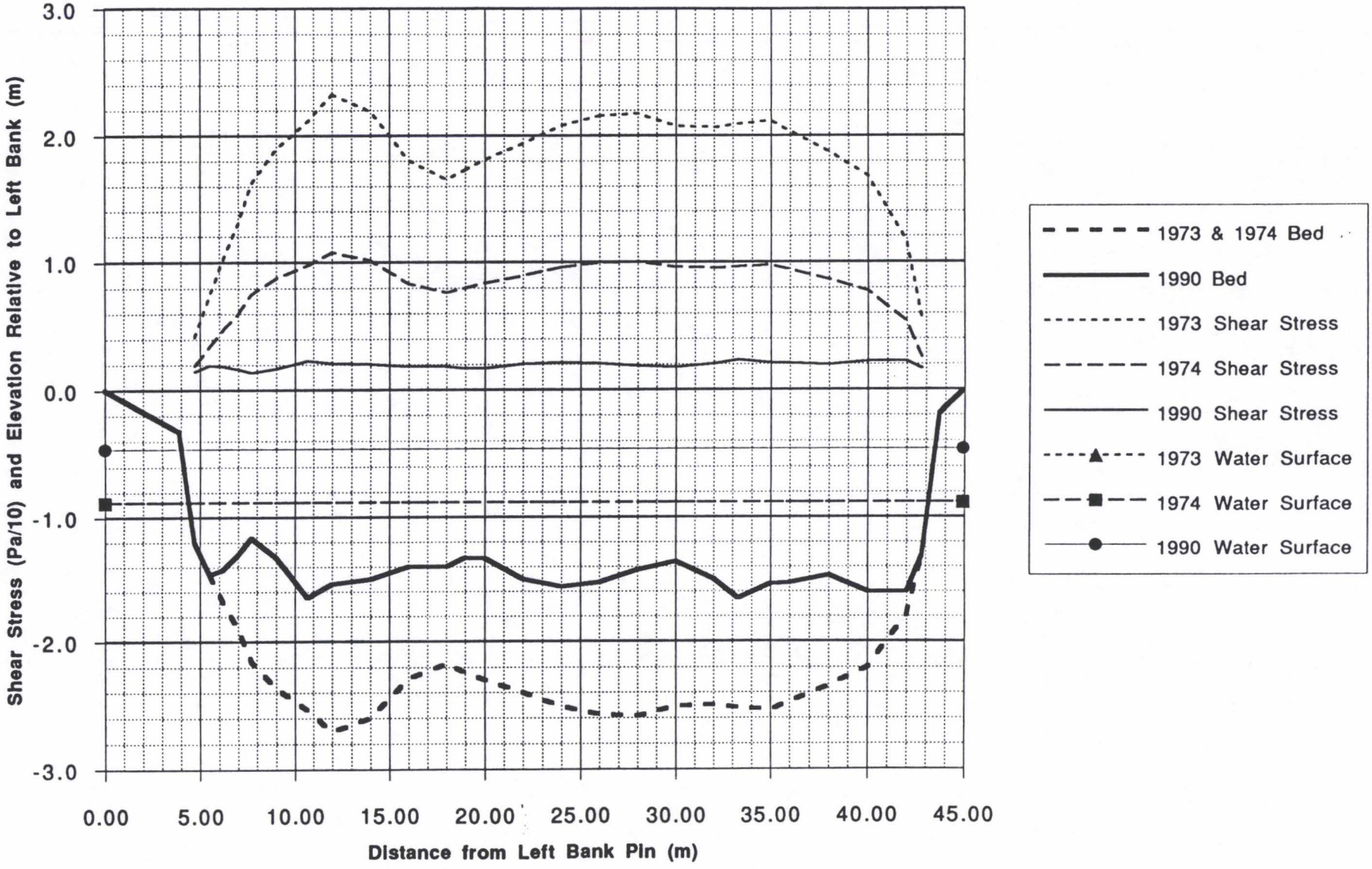
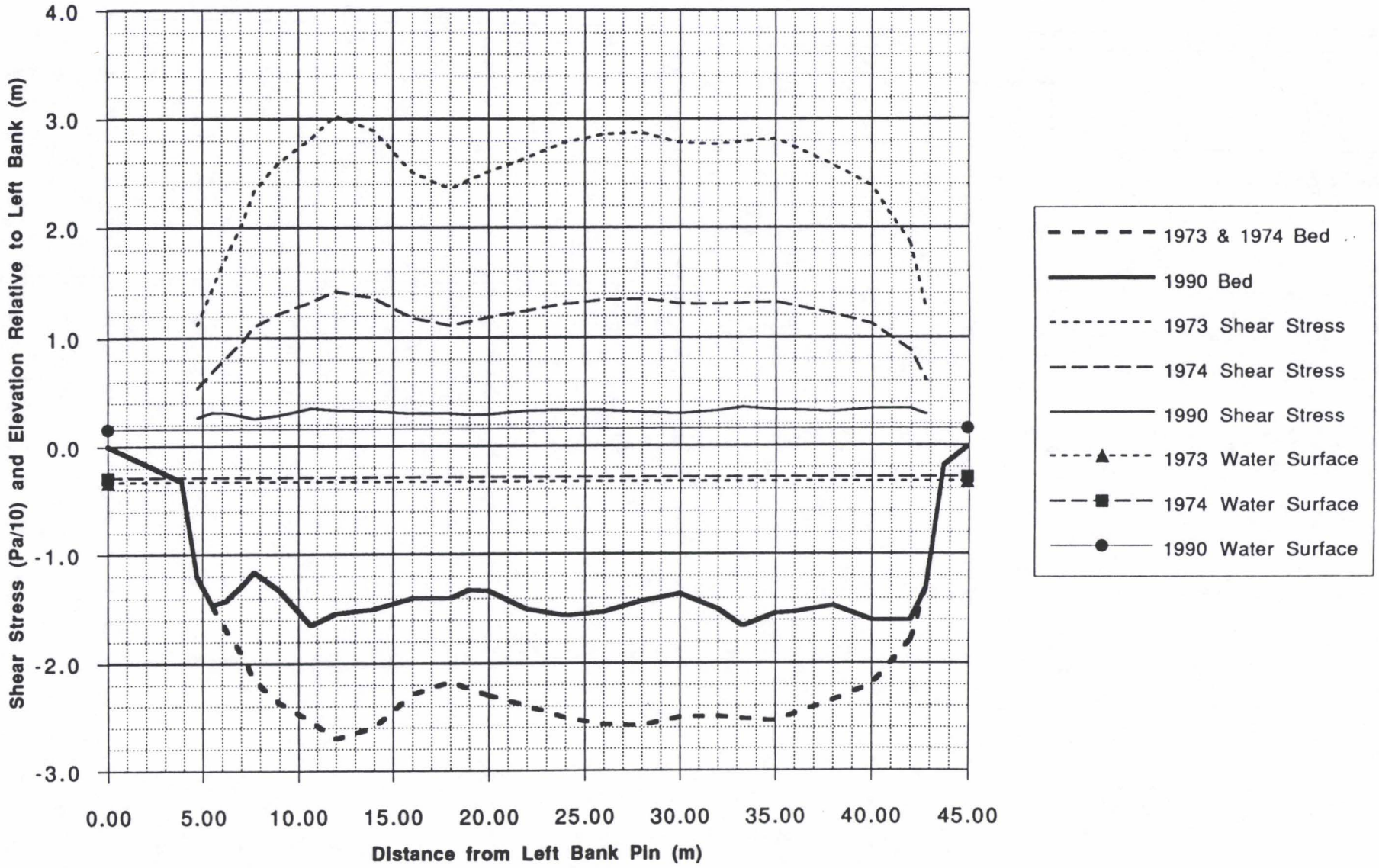


Figure 5.3.13 Cross Section 12 Bed Shear Stress at 141.6 cms (5000 cfs)



a coarser load is more difficult to transport and may cause deposition, even in the presence of a decreased sediment supply. We presume this to be the case on the SFSR, where deposition has resulted because a decrease in sediment supply may have been compensated for by an increase in sediment caliber.

The aerial photograph evidence make a strong case that some deposition has occurred in the downstream reach following the cutoff. The evidence includes bank widening, growth of the large bar immediately downstream of the breach, and the continued presence (and possibly growth) of bars further downstream between cross sections 21 and 23. This deposition has occurred in spite of the fact that we estimate that deposition in the oxbow has produced a net deficit of 8,300 m^3 in the sediment load delivered to the downstream reach since the cutoff. We hypothesize that the downstream reach has undergone net deposition in the presence of a deficit in the sediment input because the sediment load delivered to it (primarily from the breach) is considerably coarser than would have been the case in the absence of the breach. If the load has become sufficiently coarser, the capacity of the flow would be reduced to a level smaller that the diminished supply since the cutoff.

Figure 5.3.14 Downstream Sub-Reach Energy Grade Line

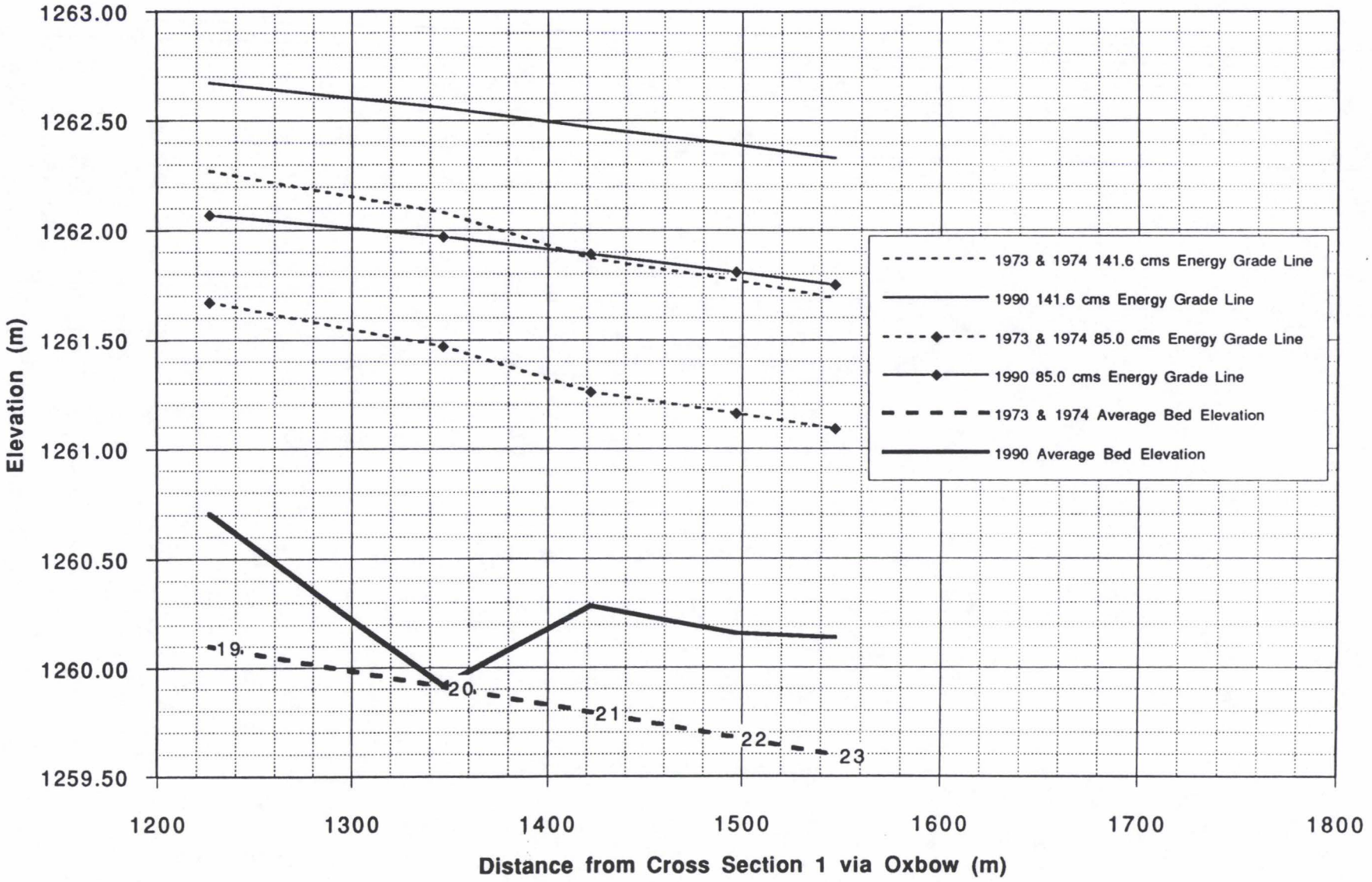
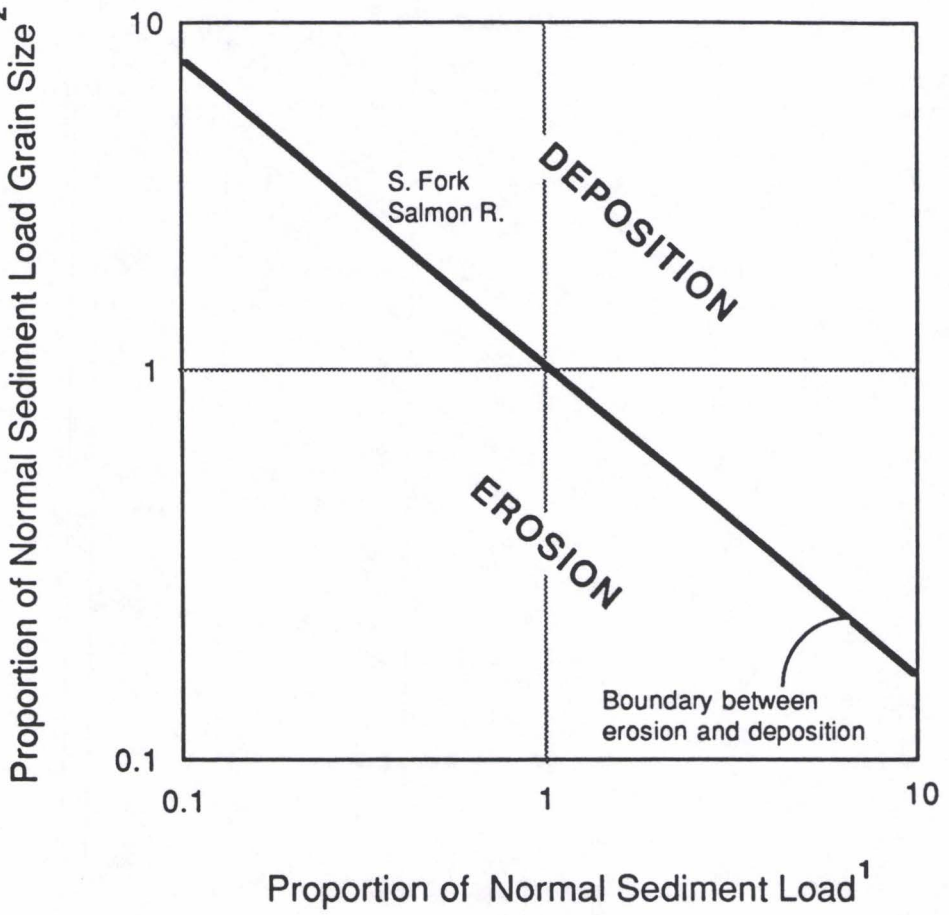


Figure 5.3.15 Schematic illustration of the downstream impact of a bend cutoff.



Notes

Normal Sediment Load is the load that would have been delivered to the downstream section in the absence of a cutoff.

1(upstream erosion rate + breach erosion rate - oxbow filling rate) / normal river sediment load
2 function of the grain size of oxbow fill, breach erosion, and upstream bed scour relative to normal river sediment load

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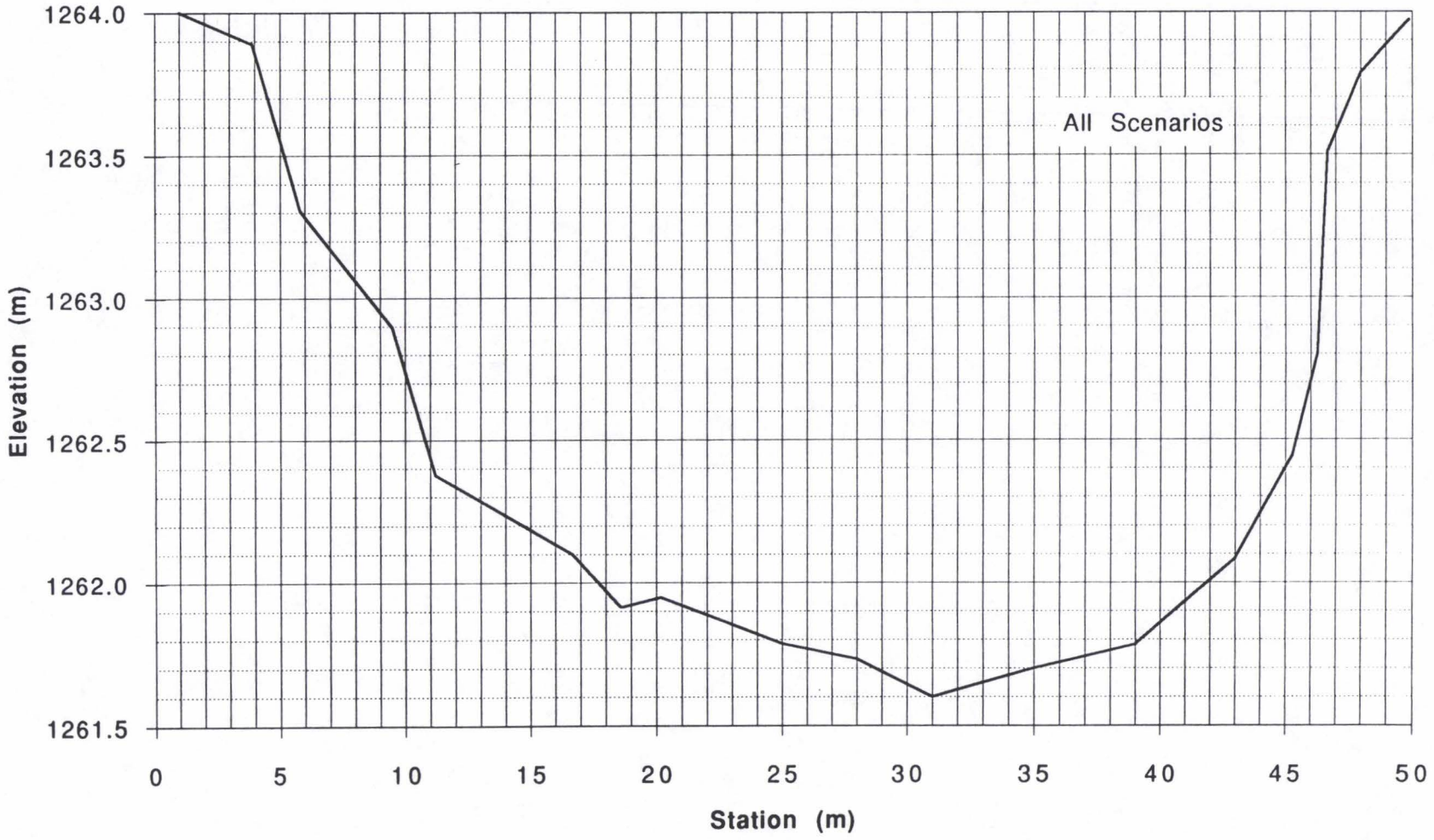
APPENDIX A

CHANNEL CROSS SECTIONS

SFSR Cross Section 1



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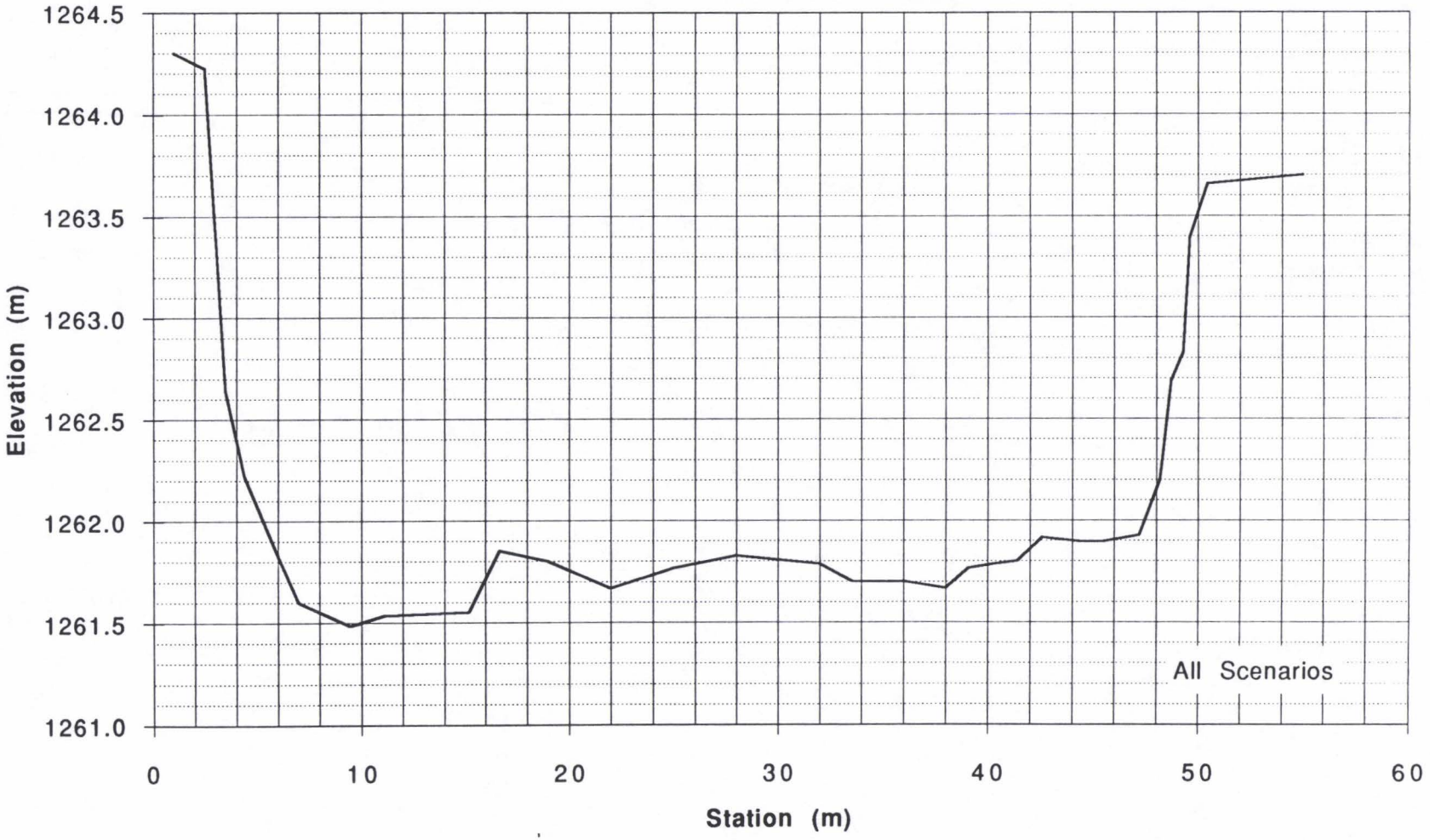
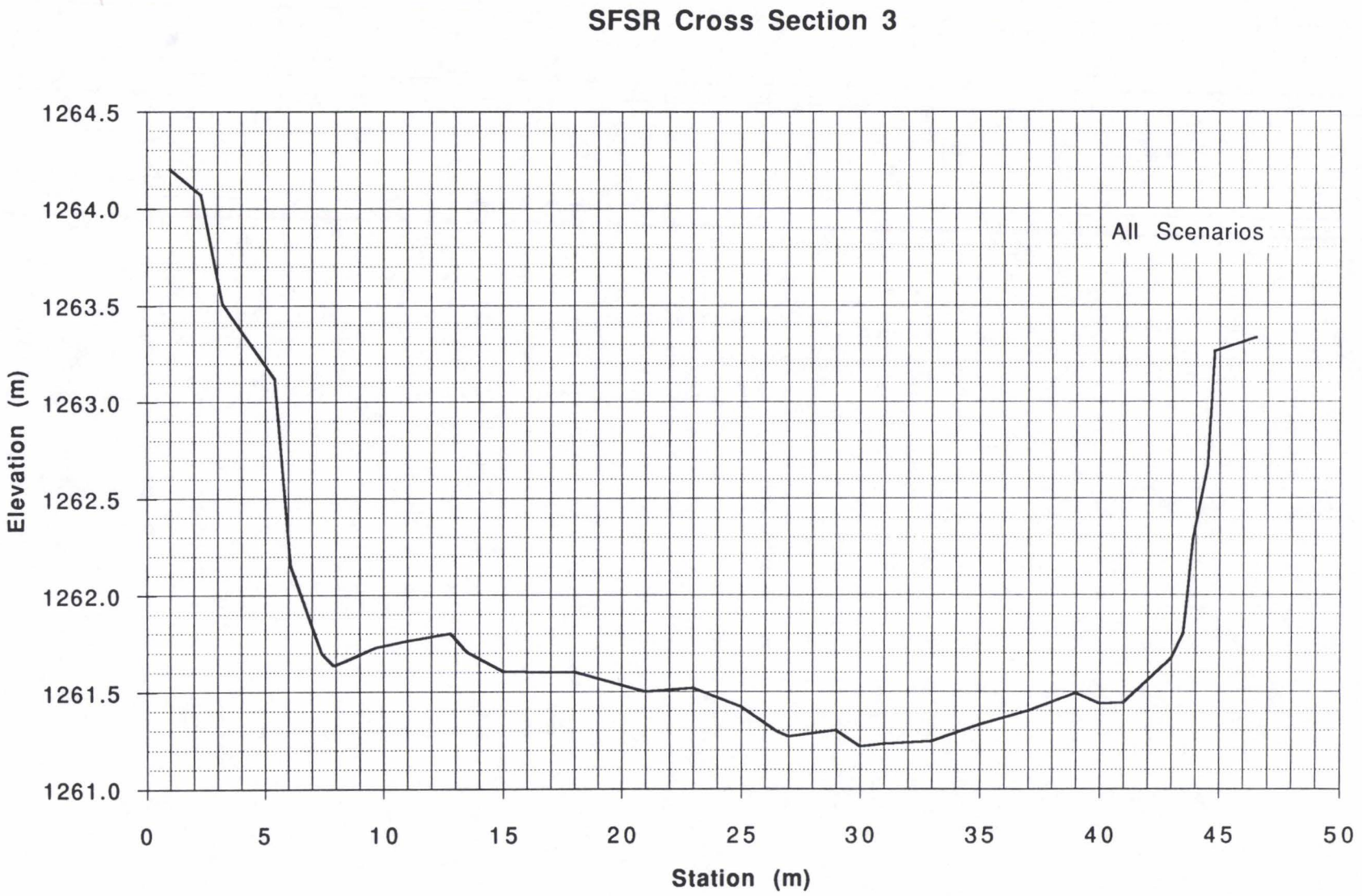
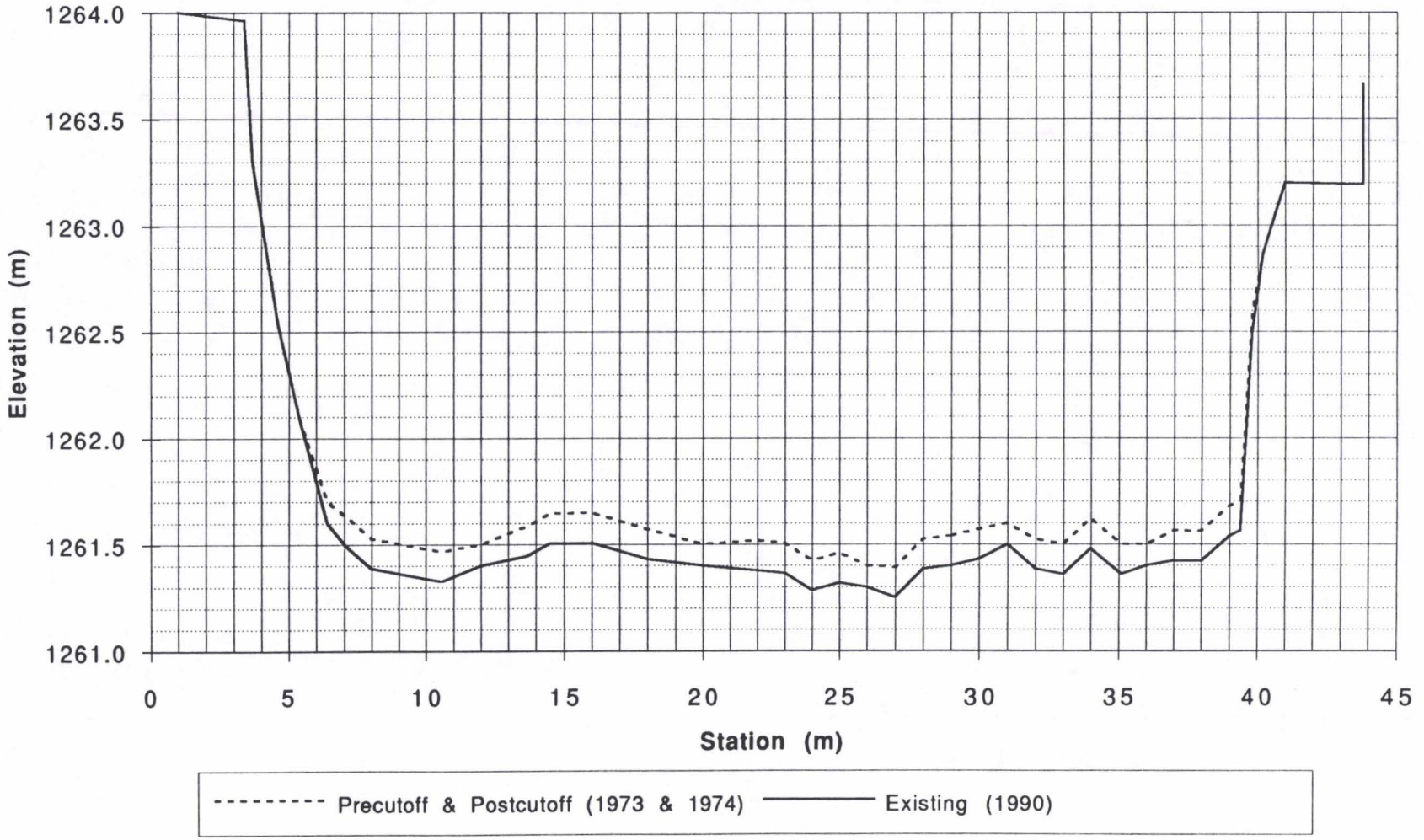



SFSR Cross Section 3
1264.5
1264.0
1263.5
1263.0
1262.5
1262.0
1261.5
1261.0
Elevation (m)
All Scenarios
0
5
10
15
20
25
30
35
40
45
50
Station (m)

SFSR Cross Section 4



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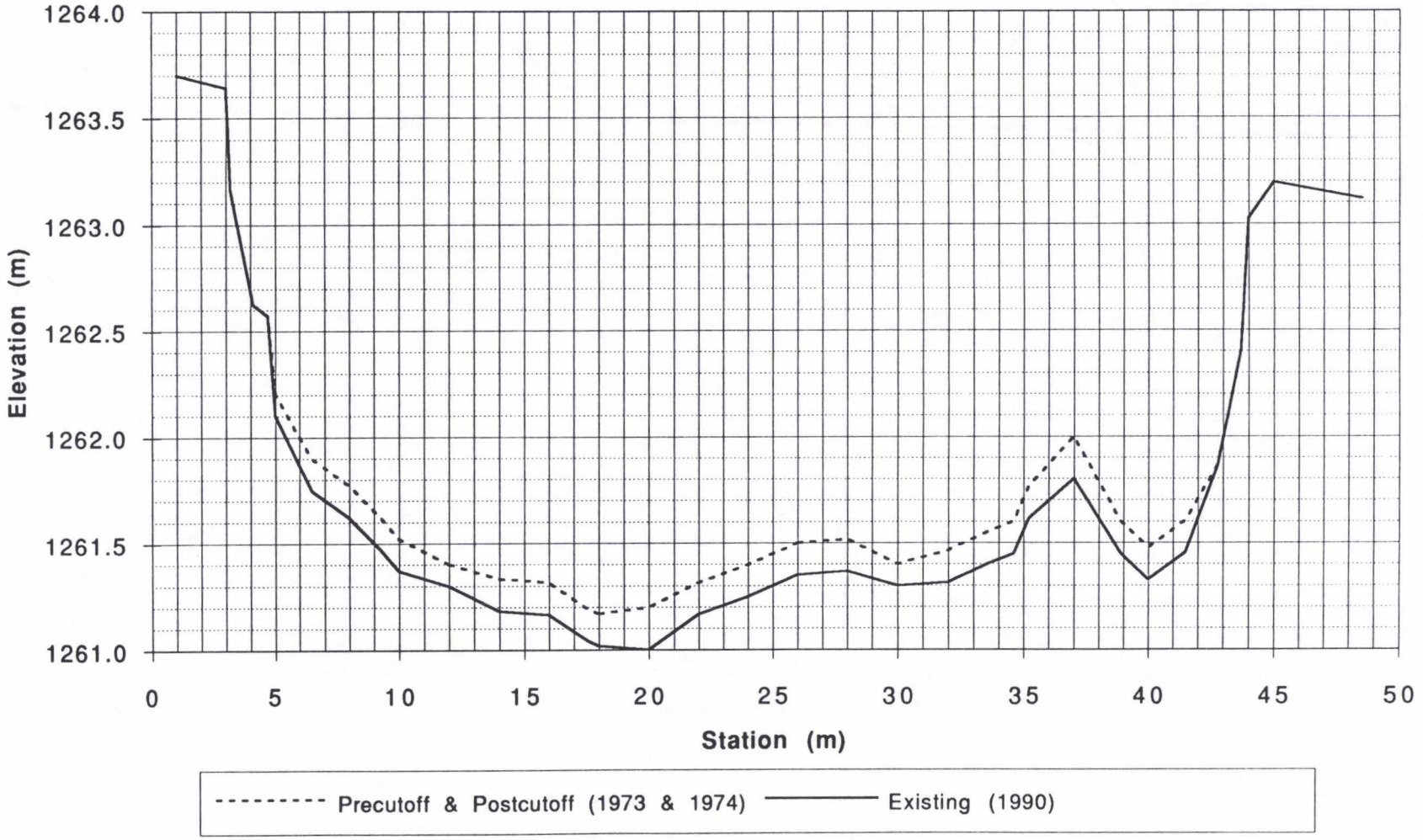

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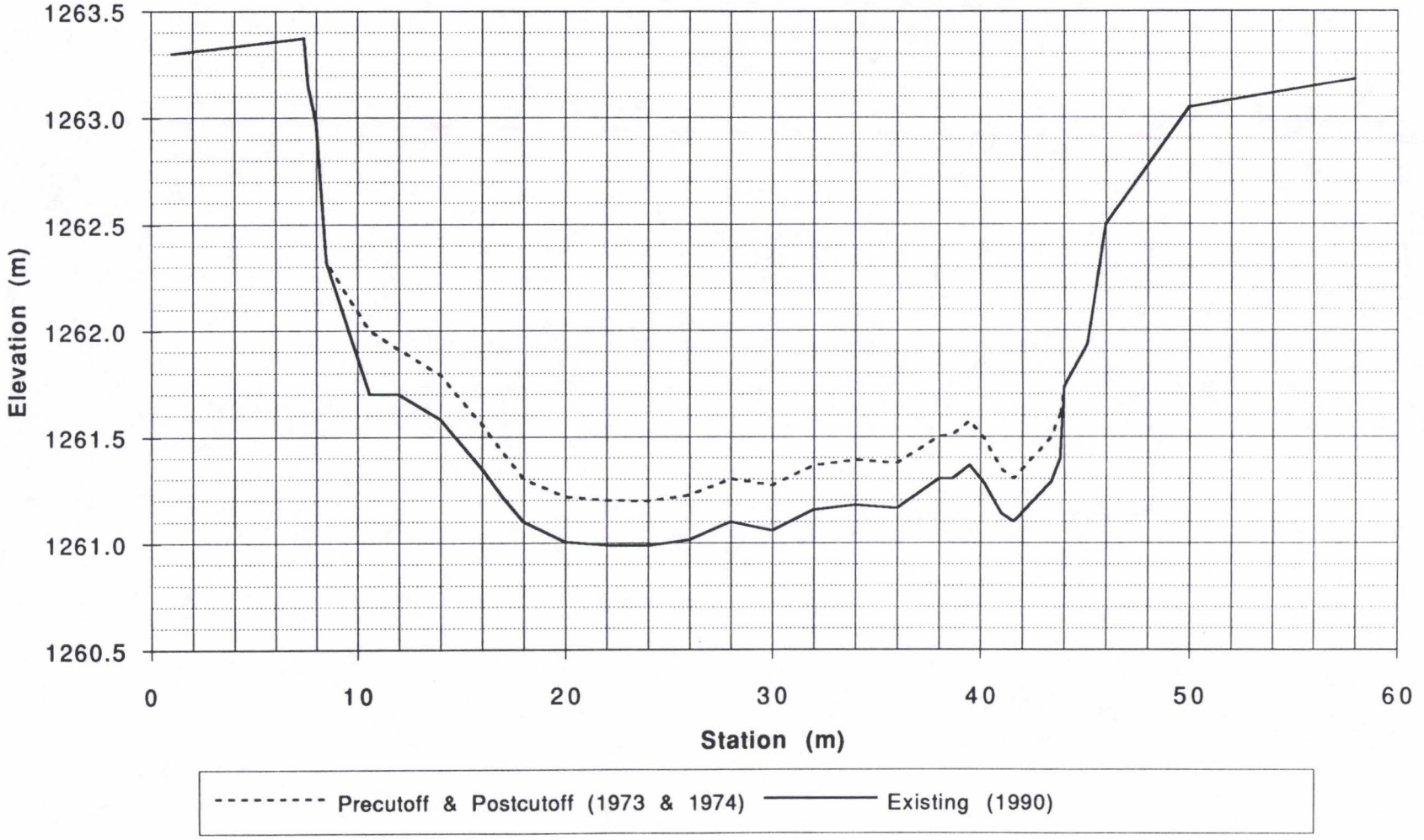

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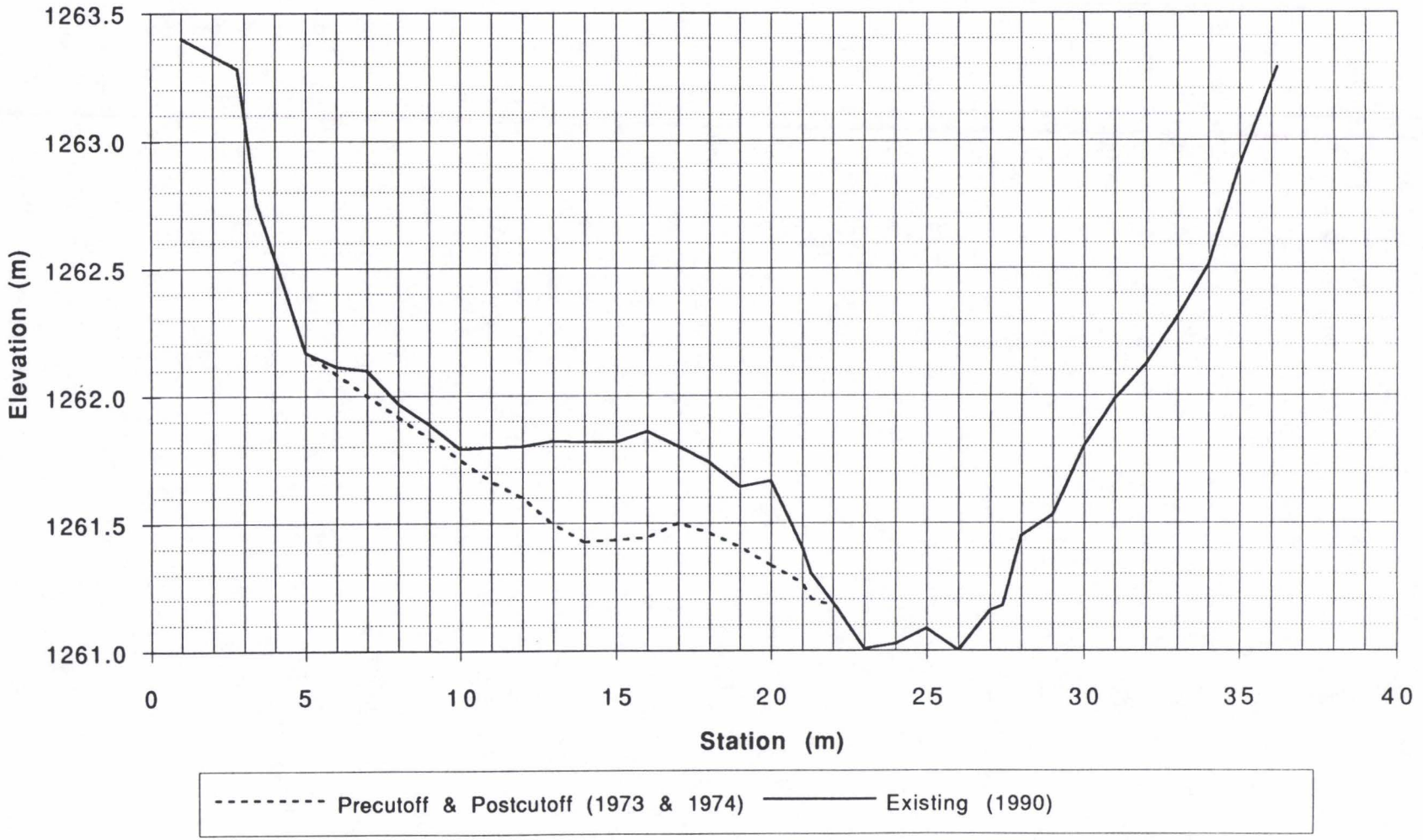

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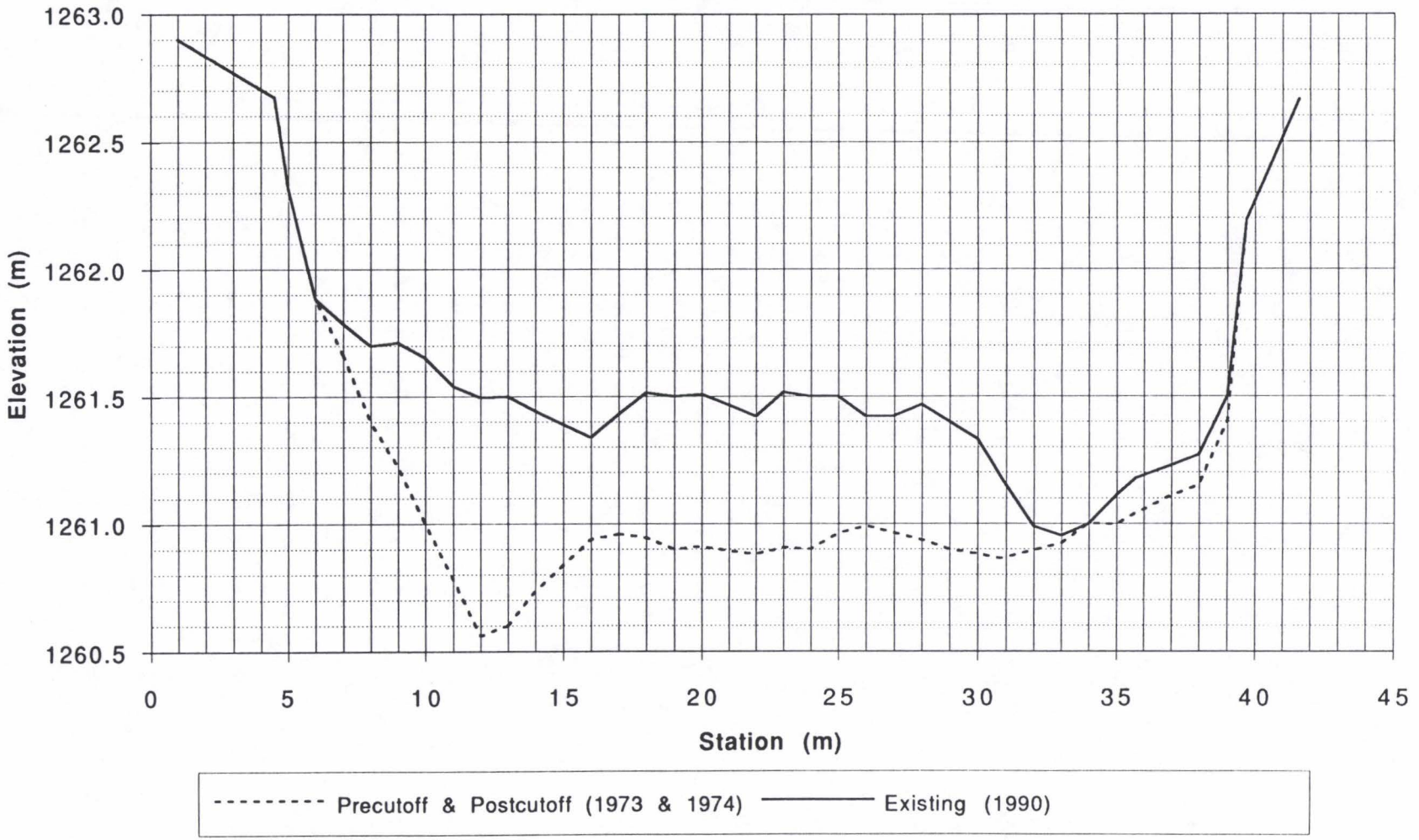

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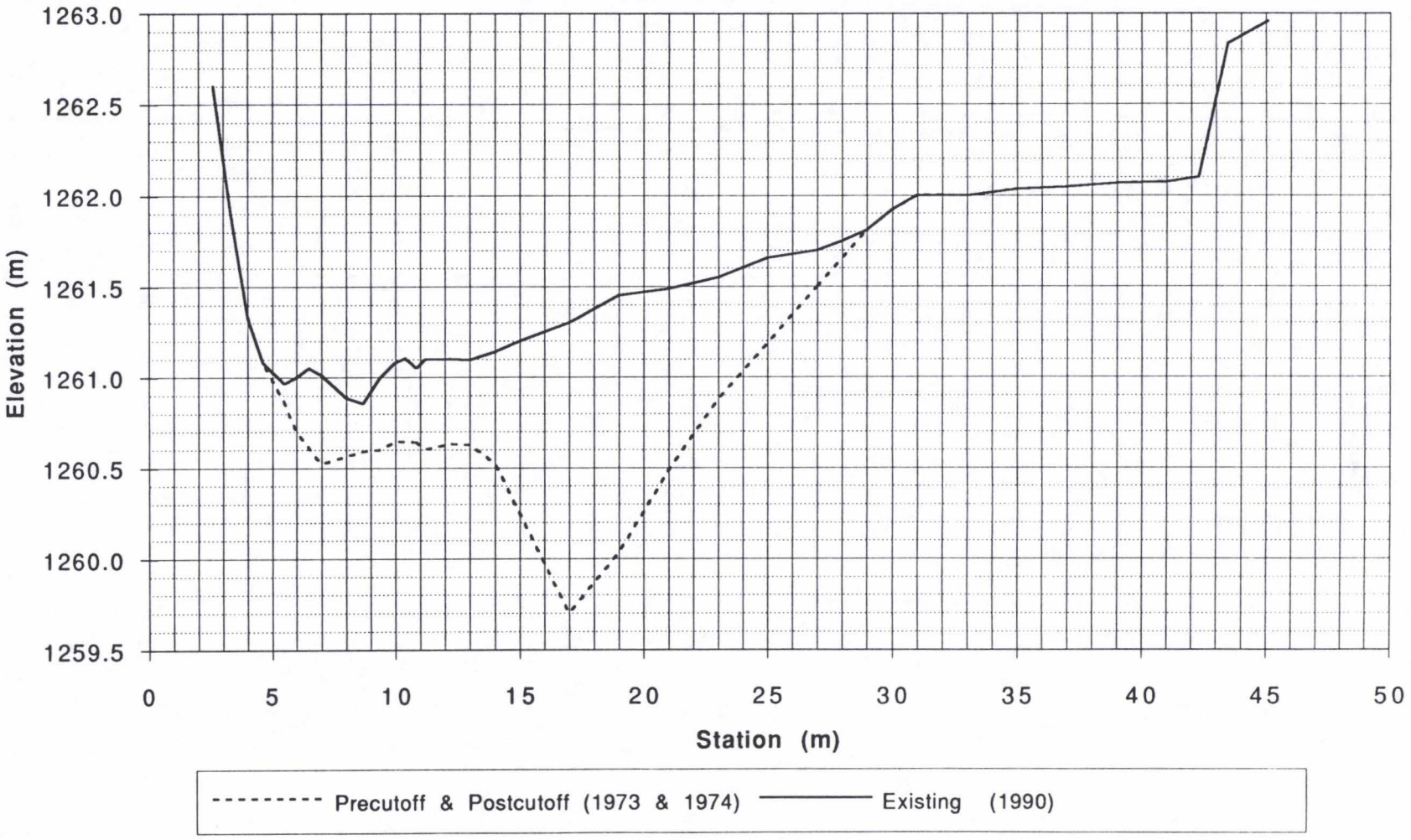

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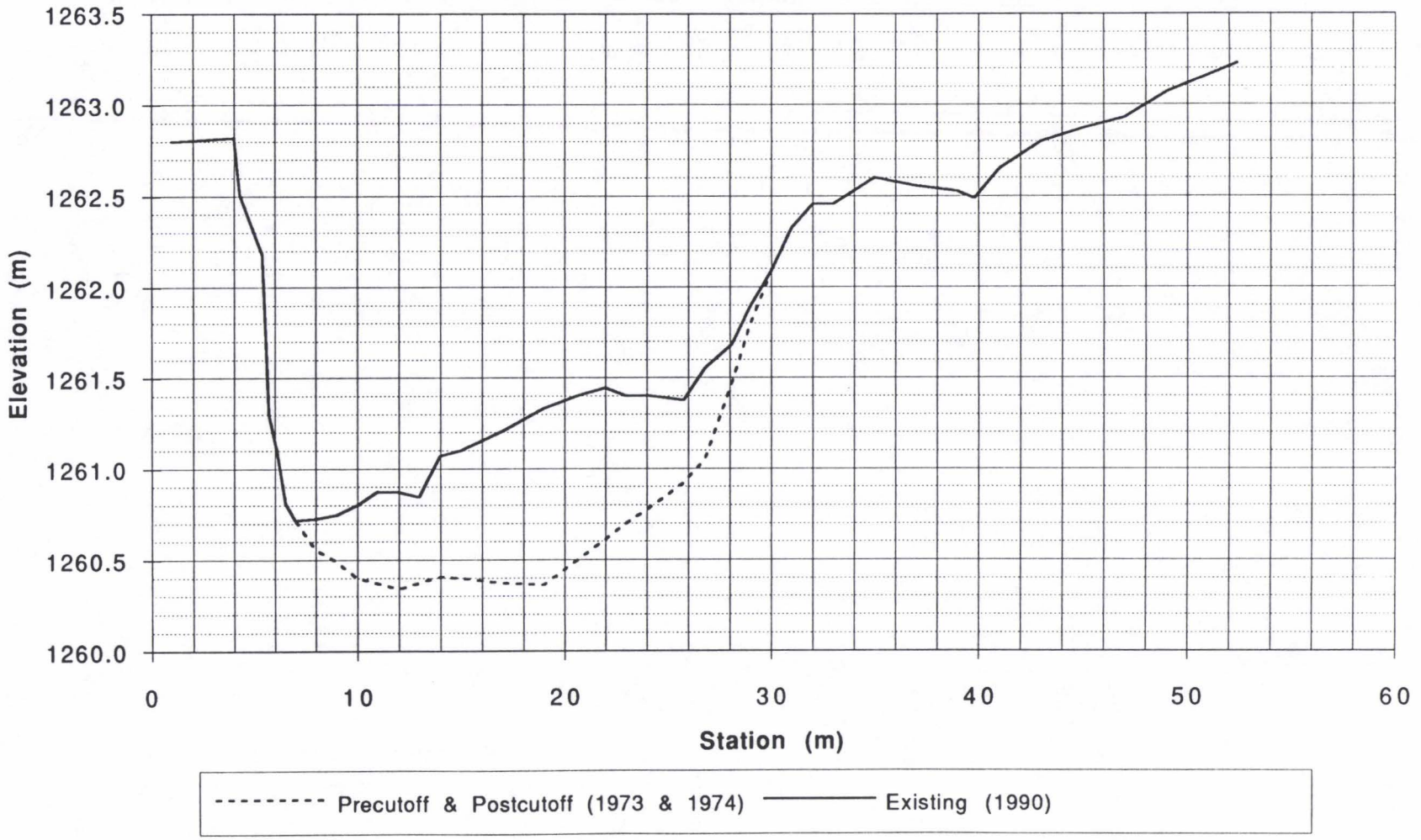

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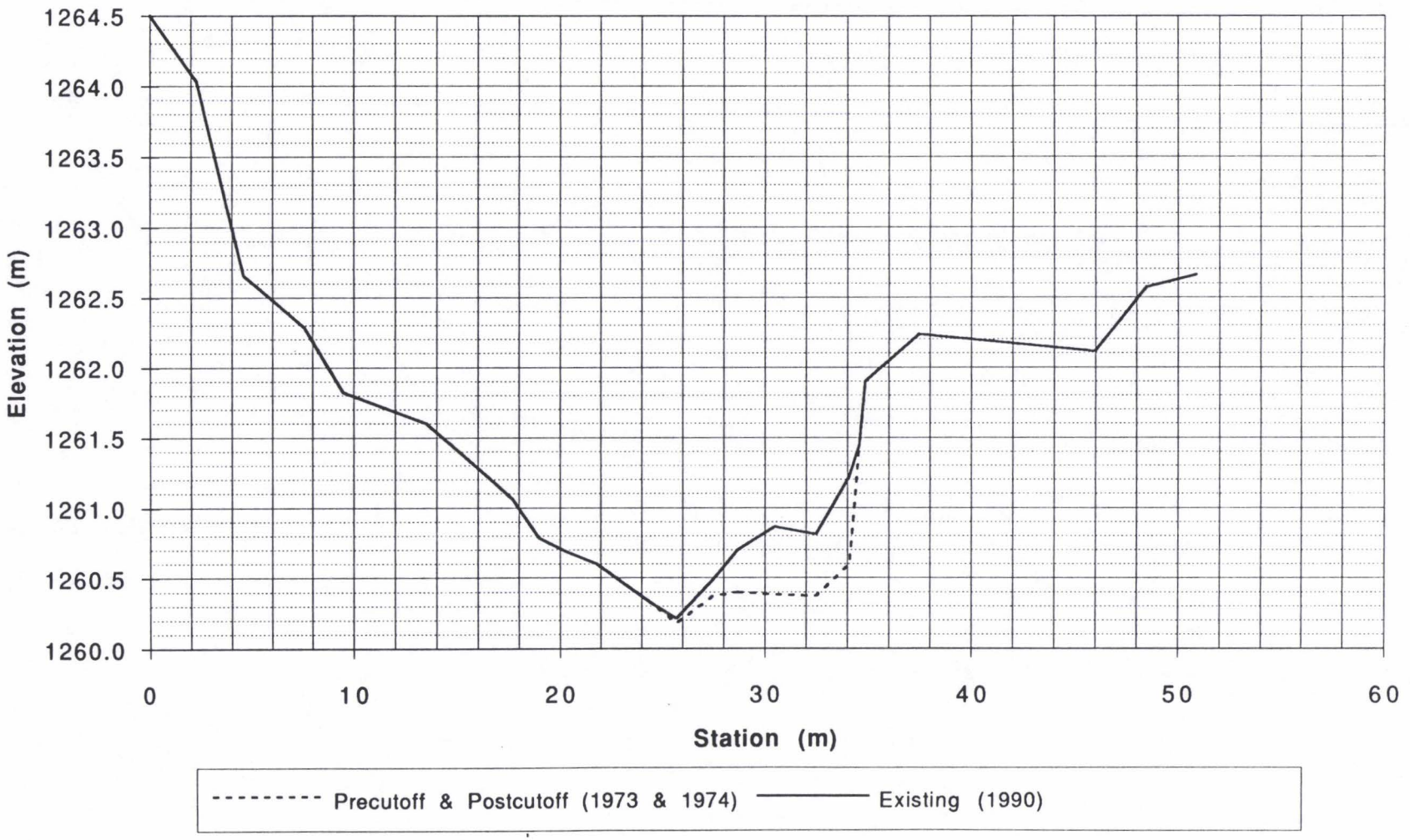

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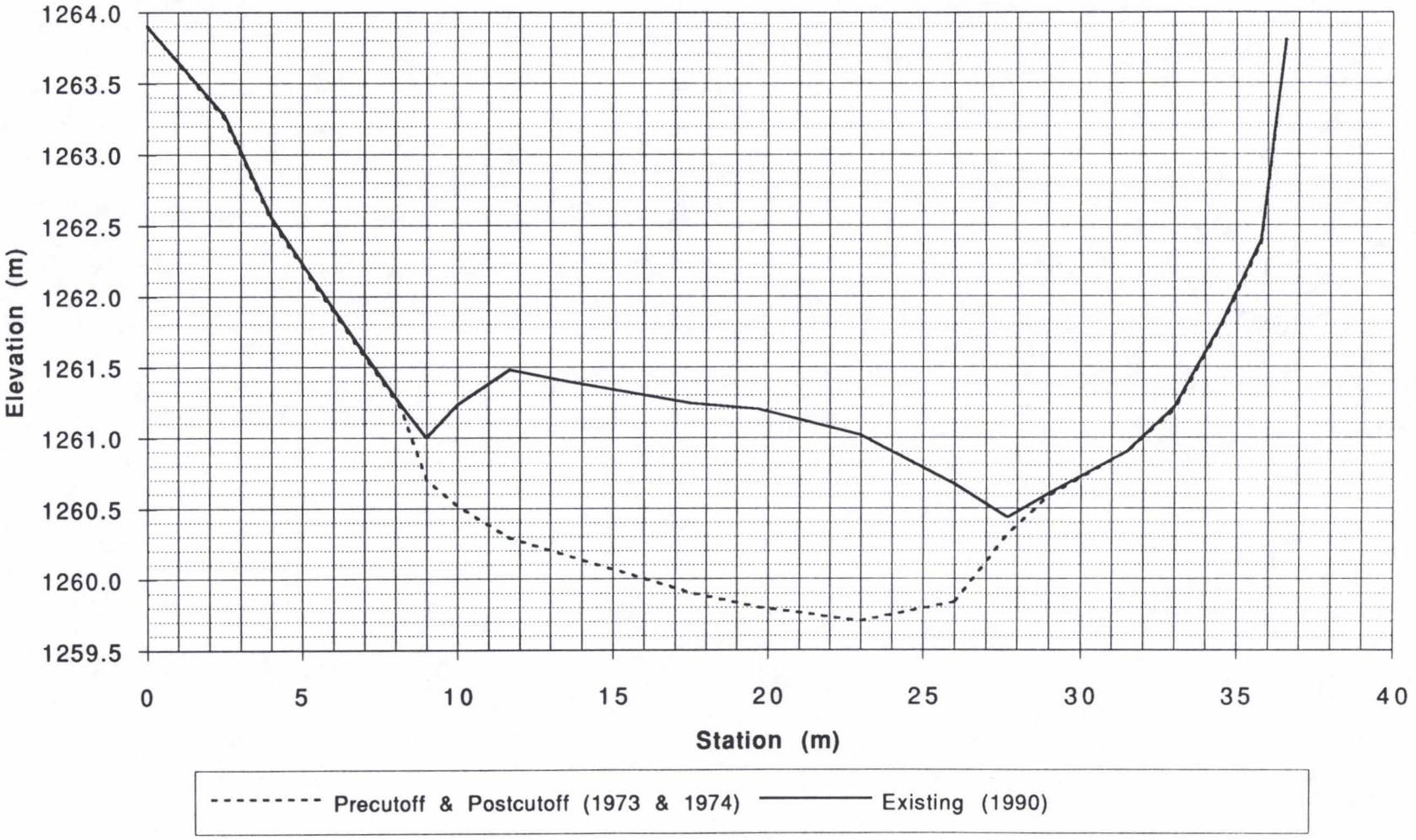

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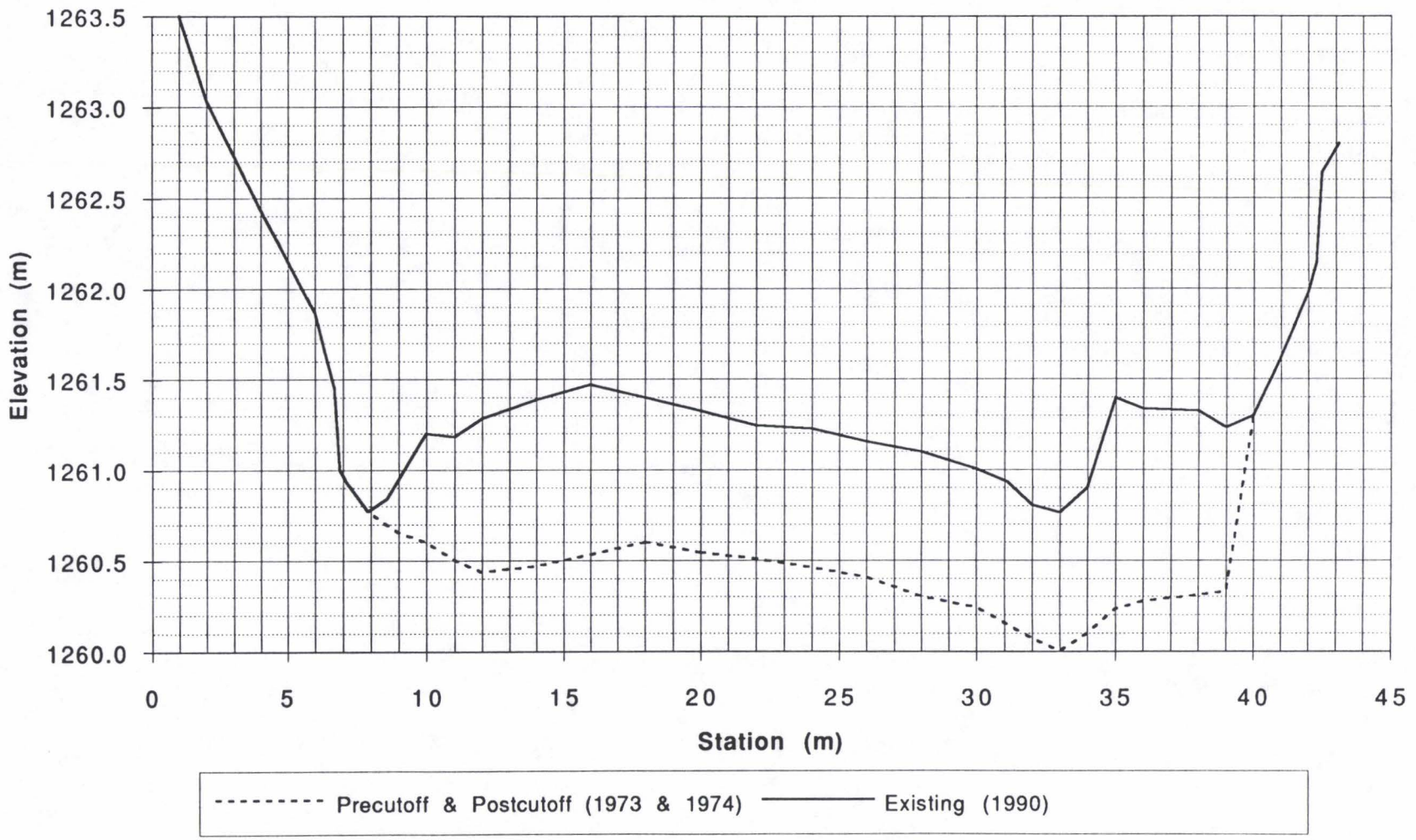

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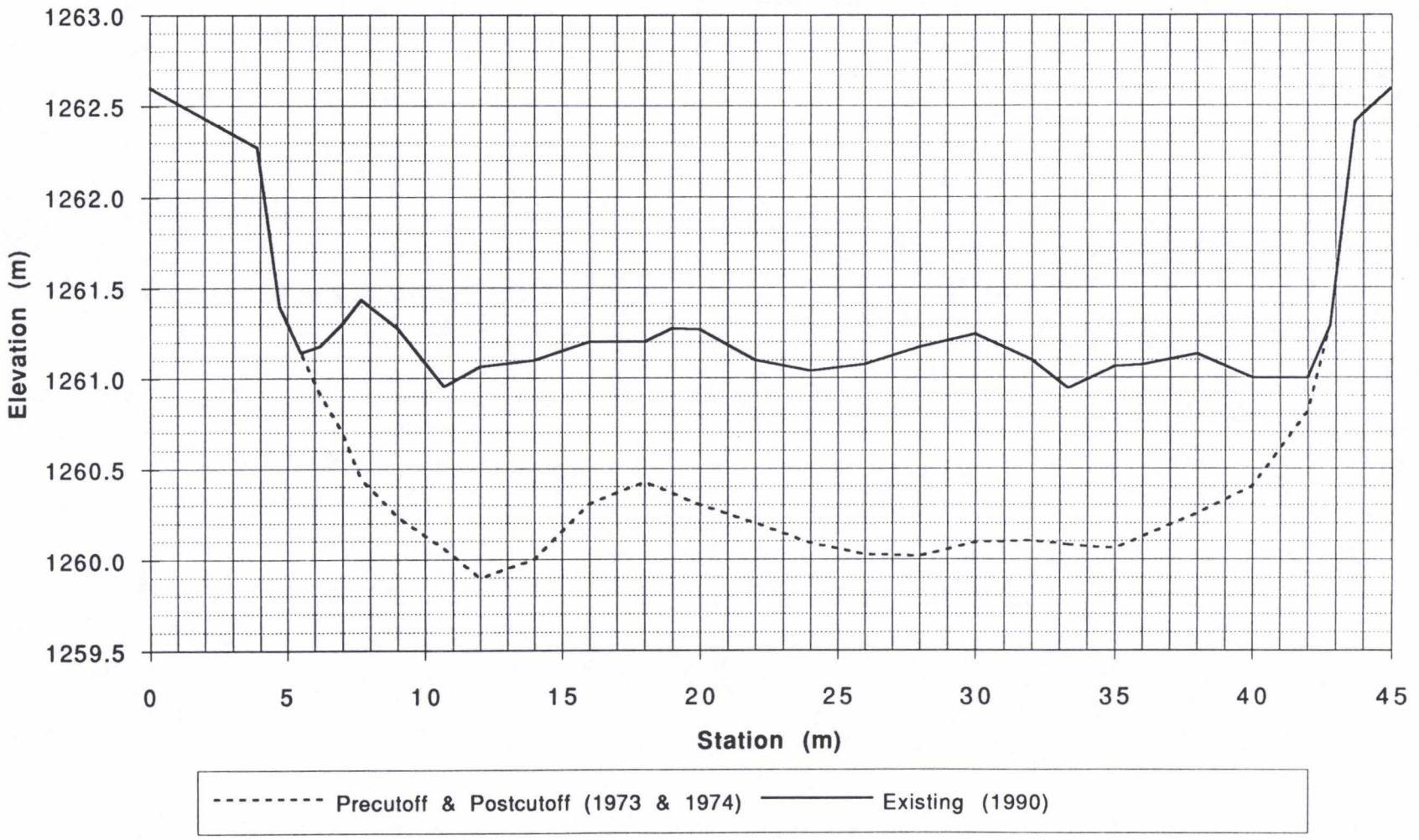

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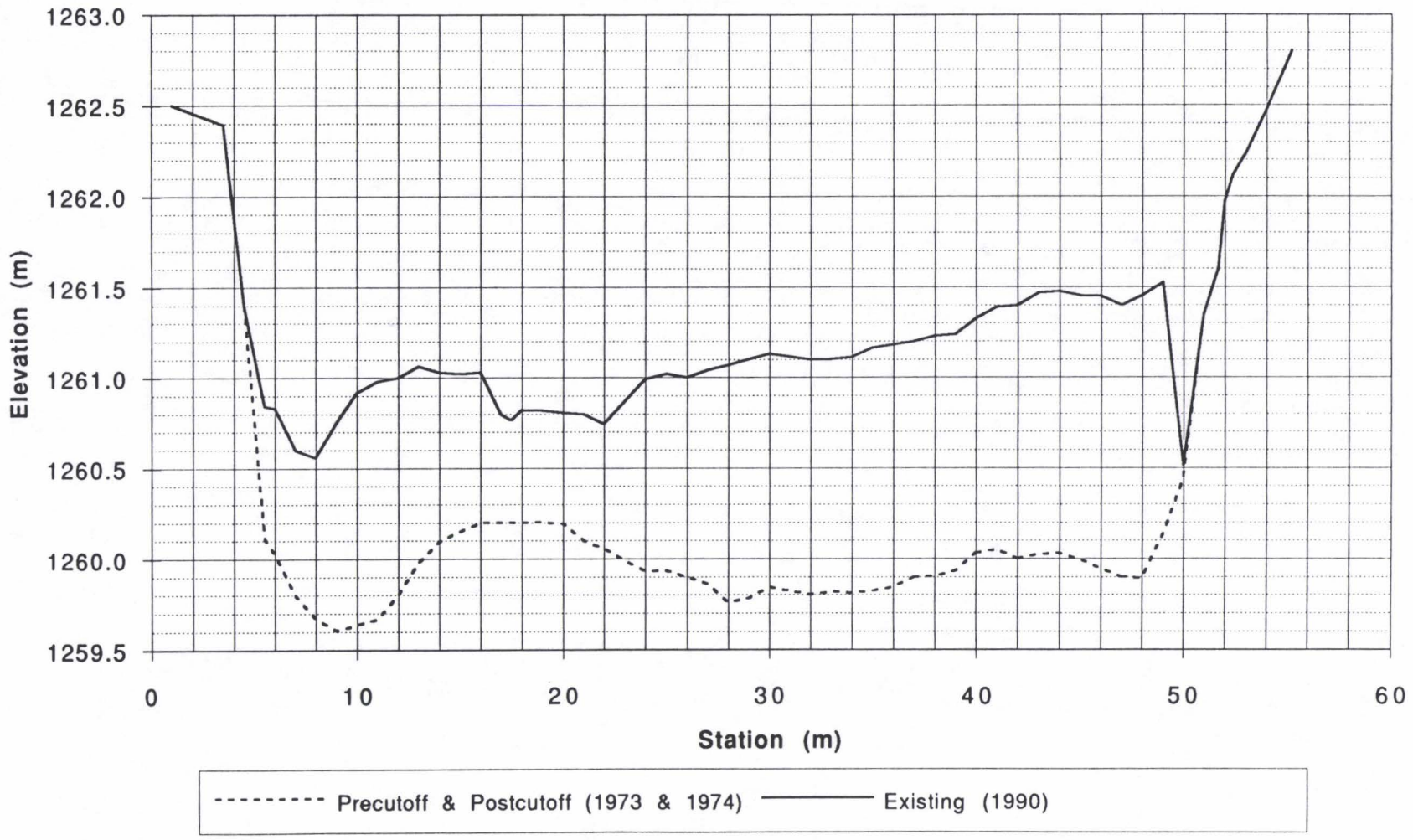

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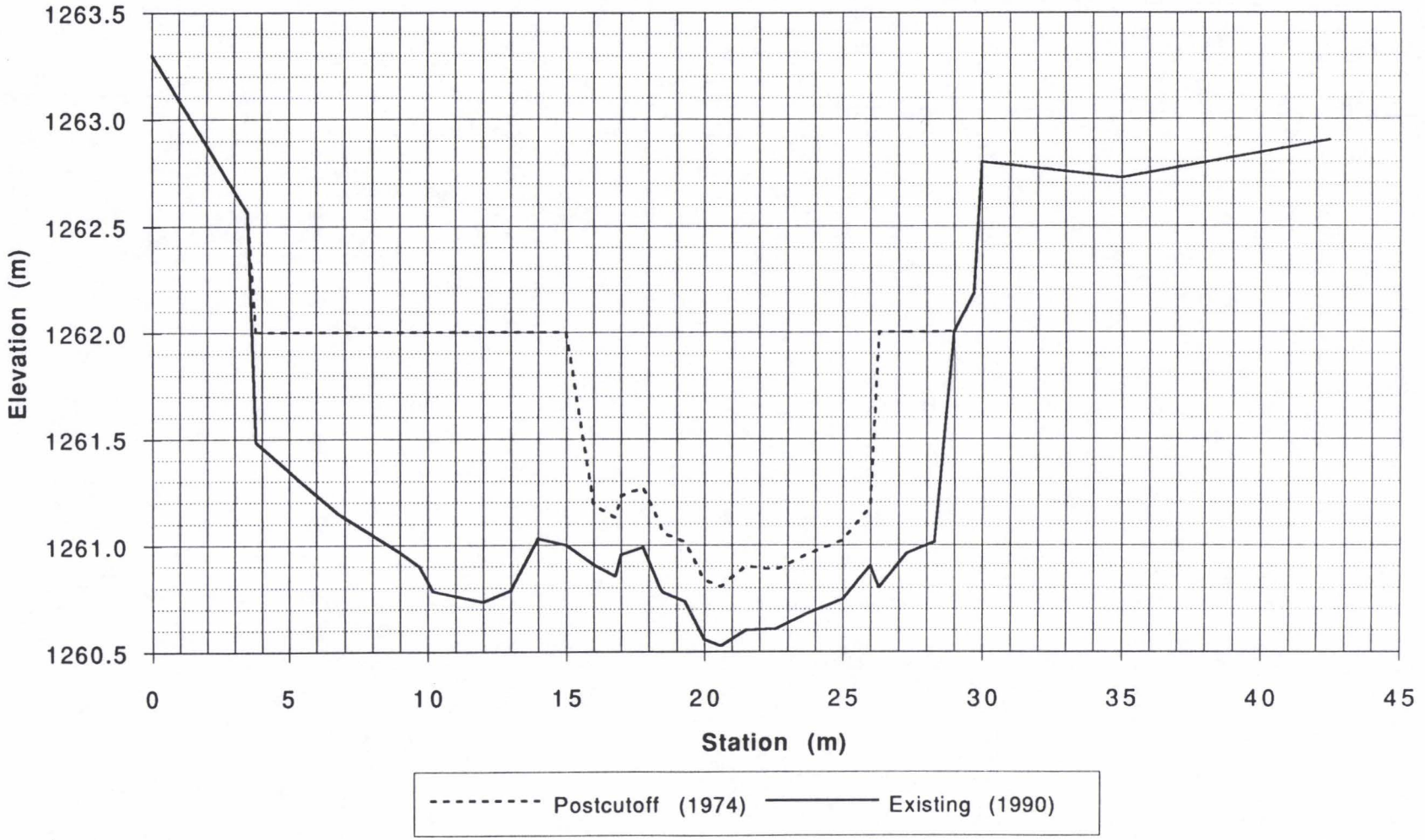

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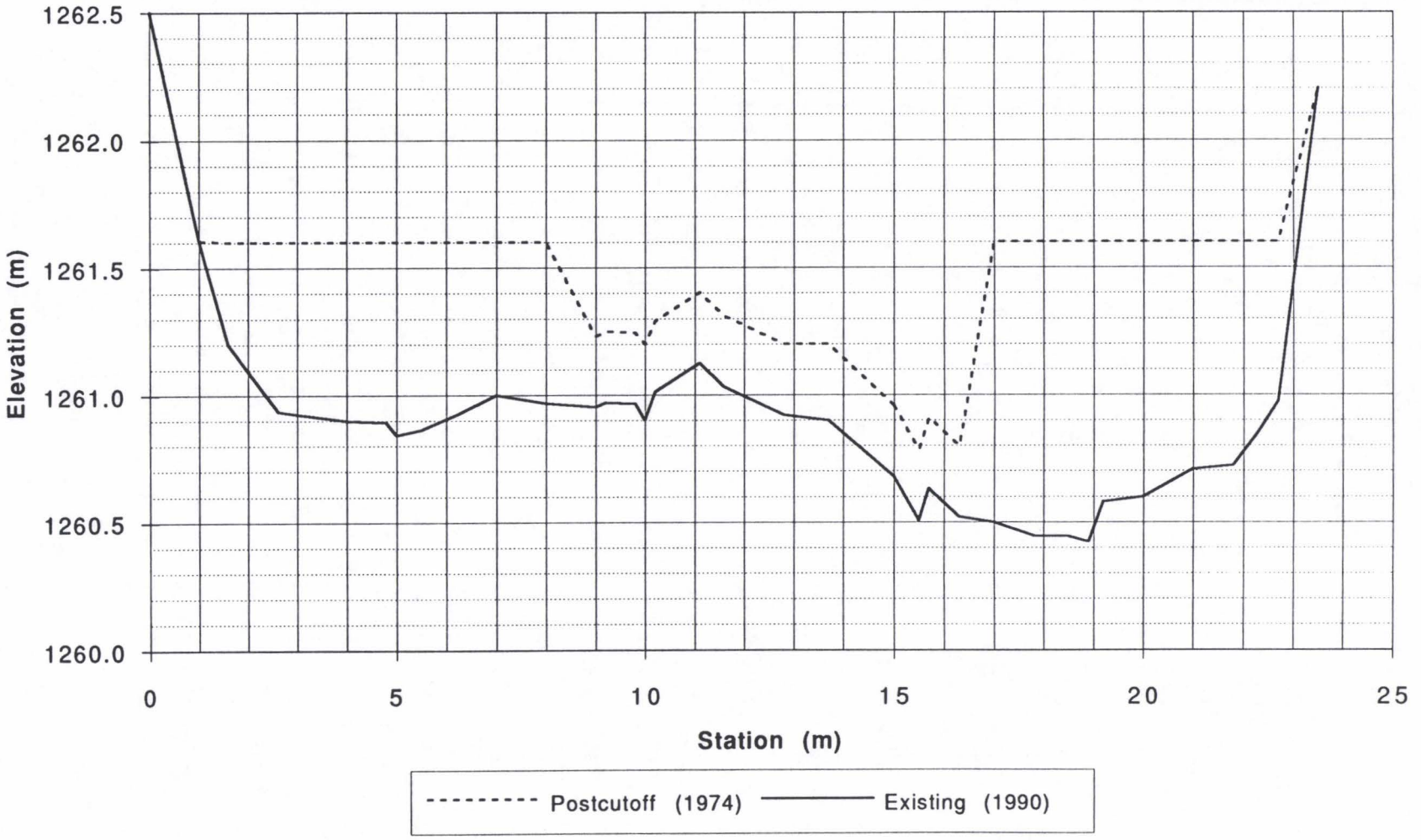

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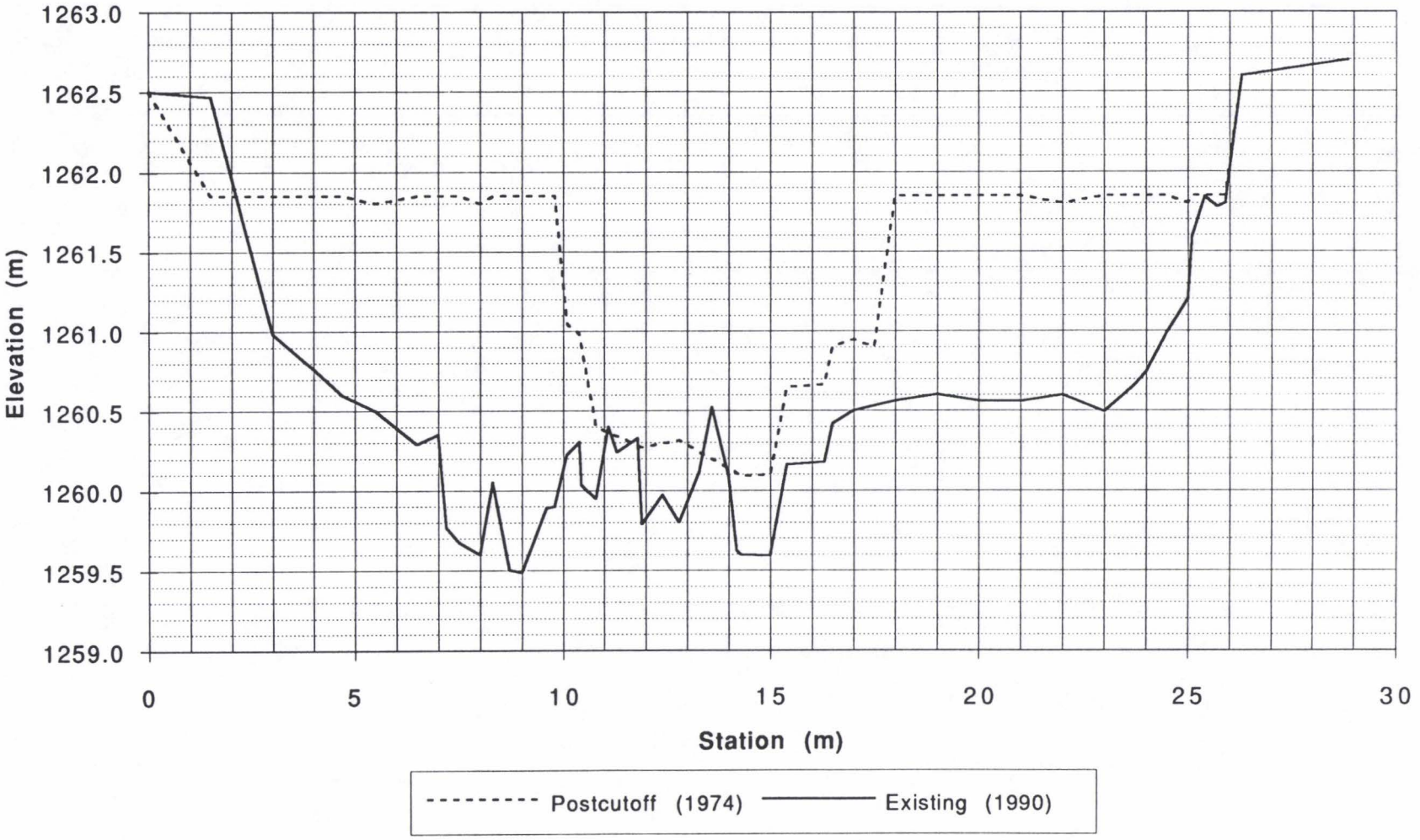

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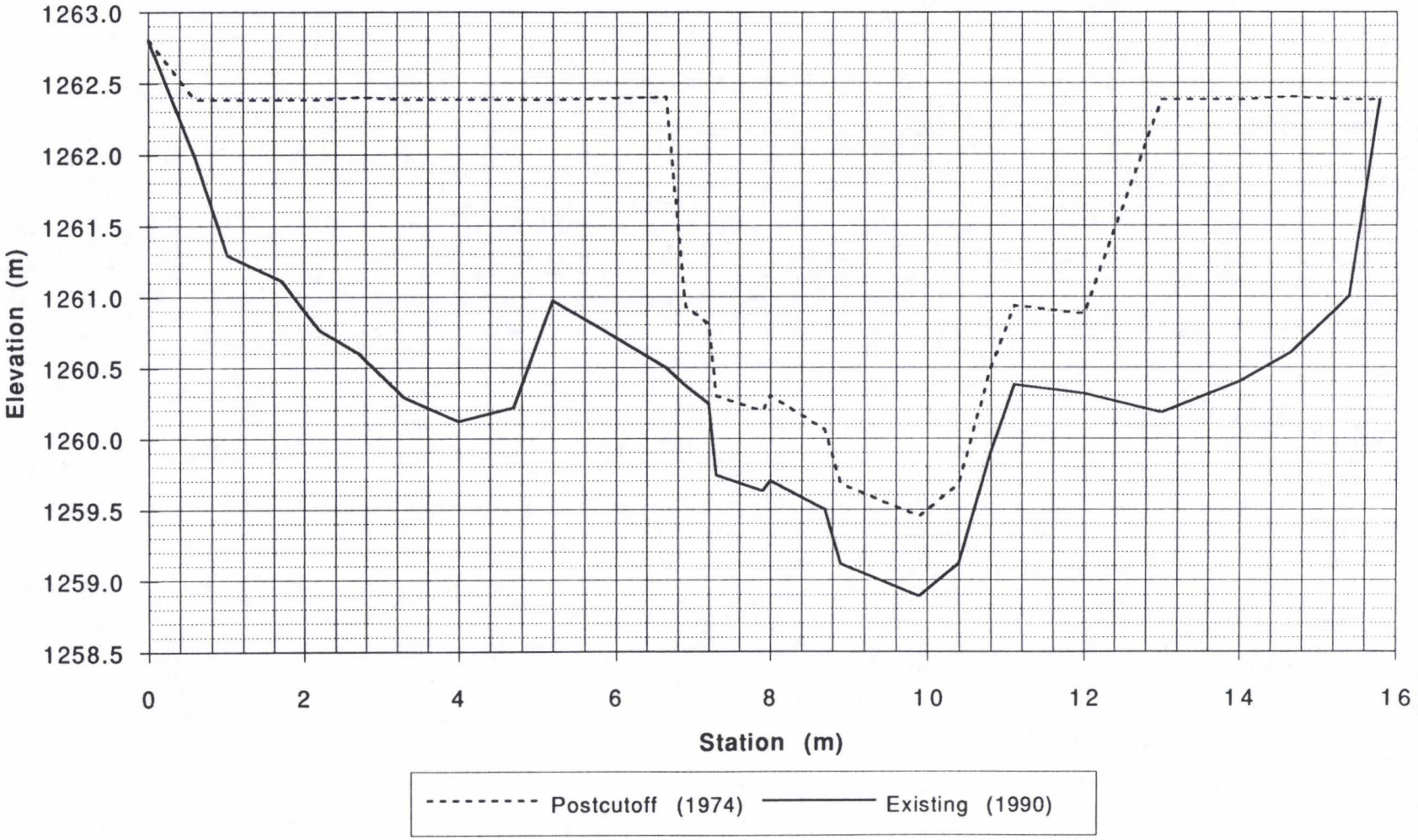

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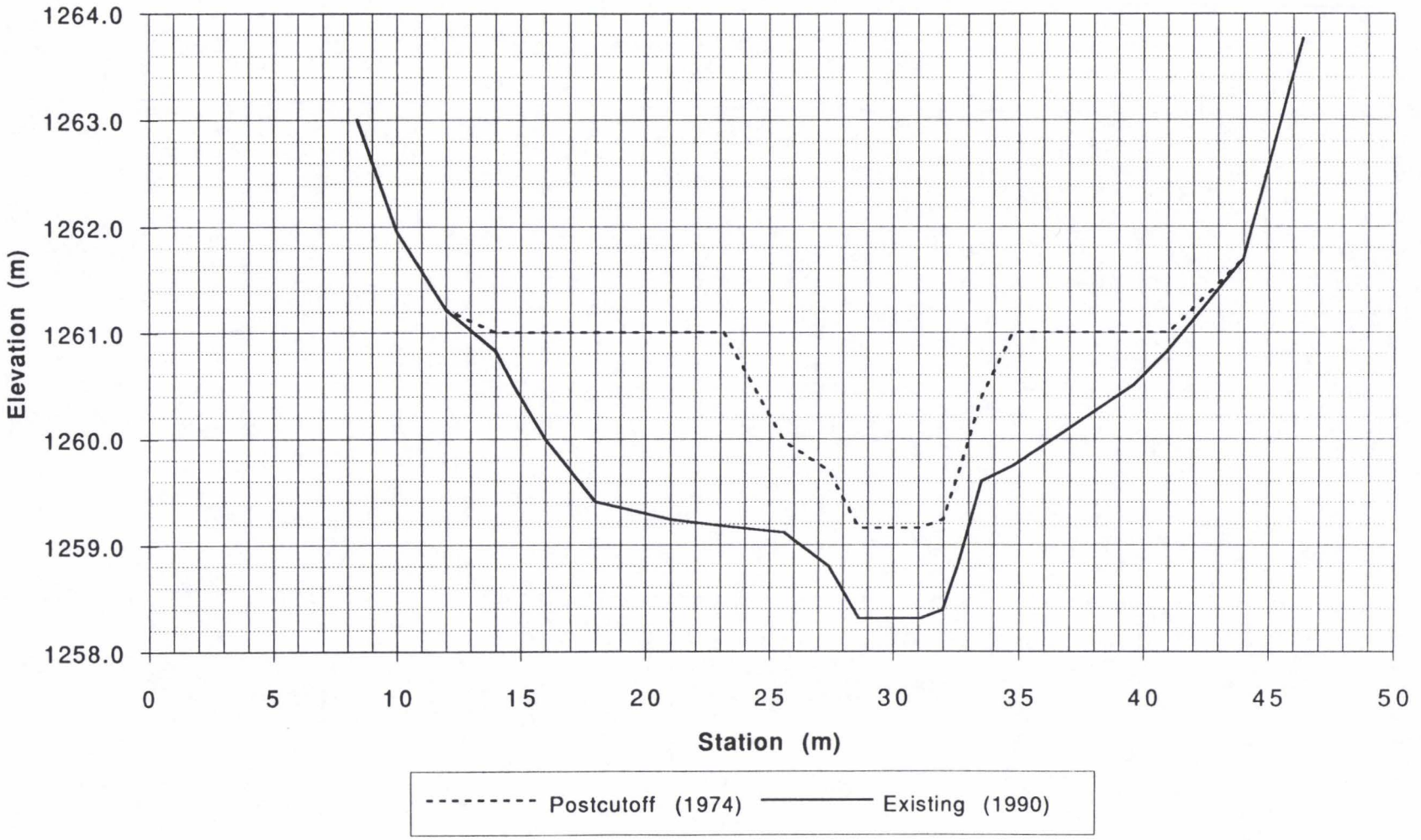
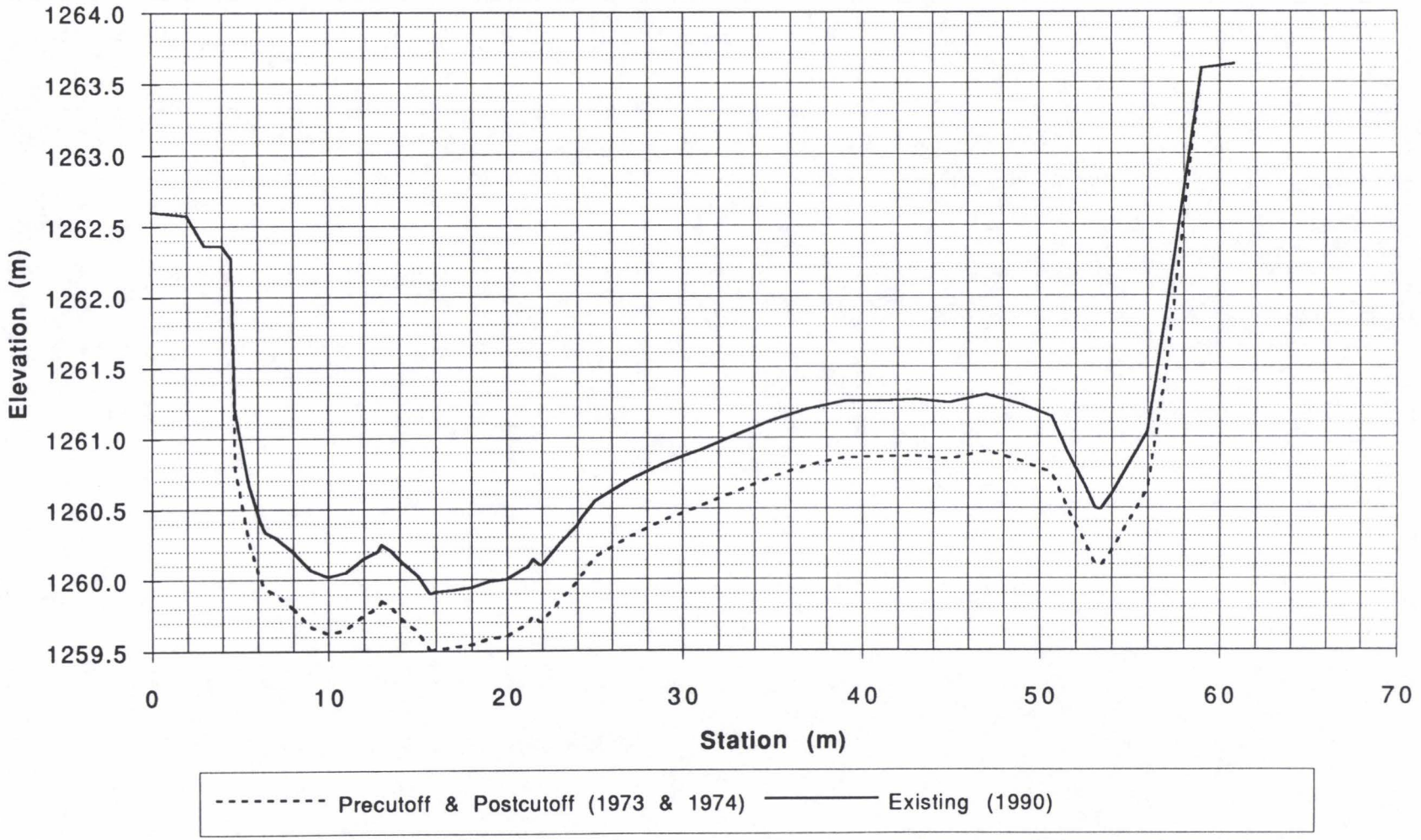
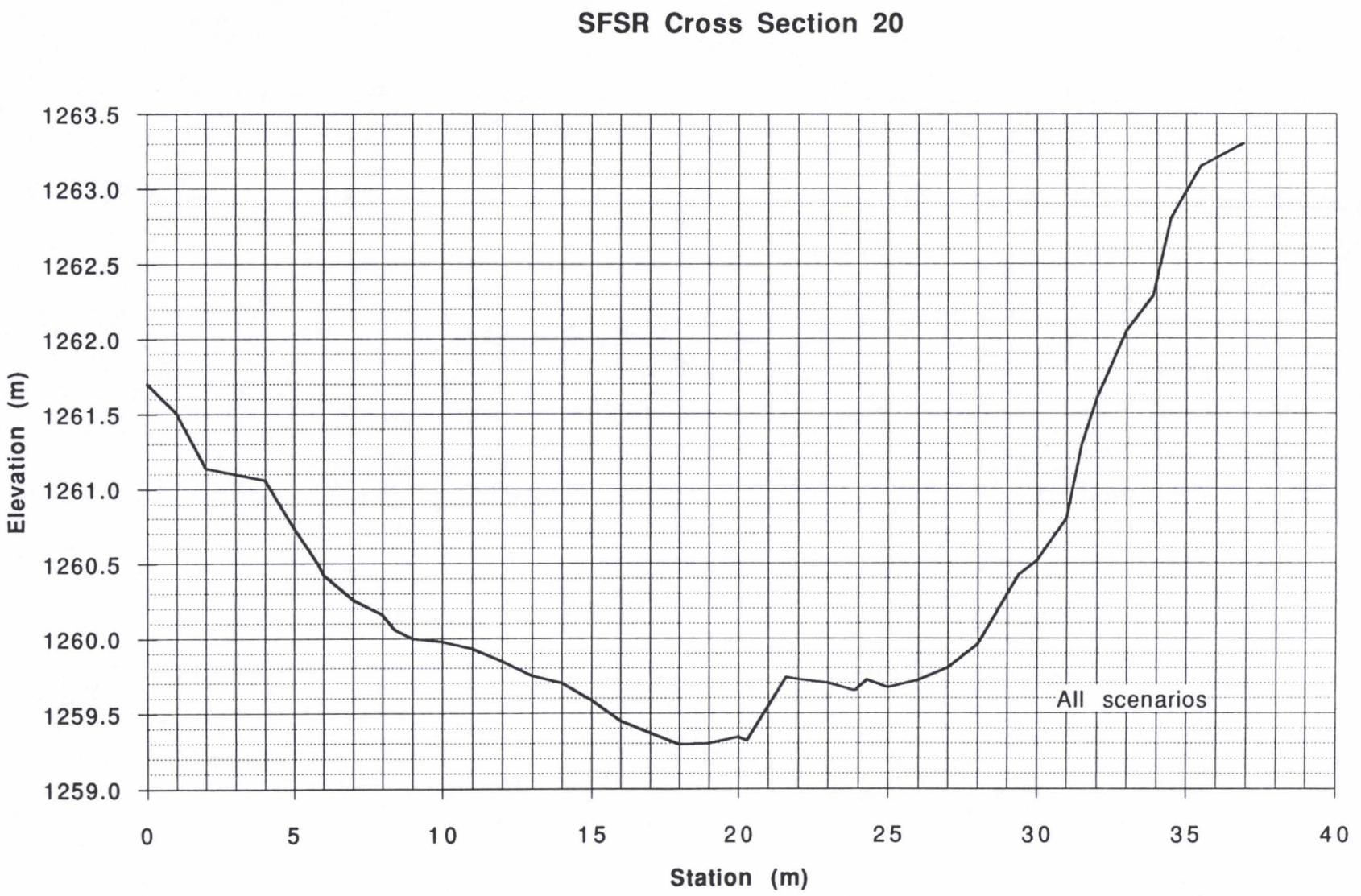
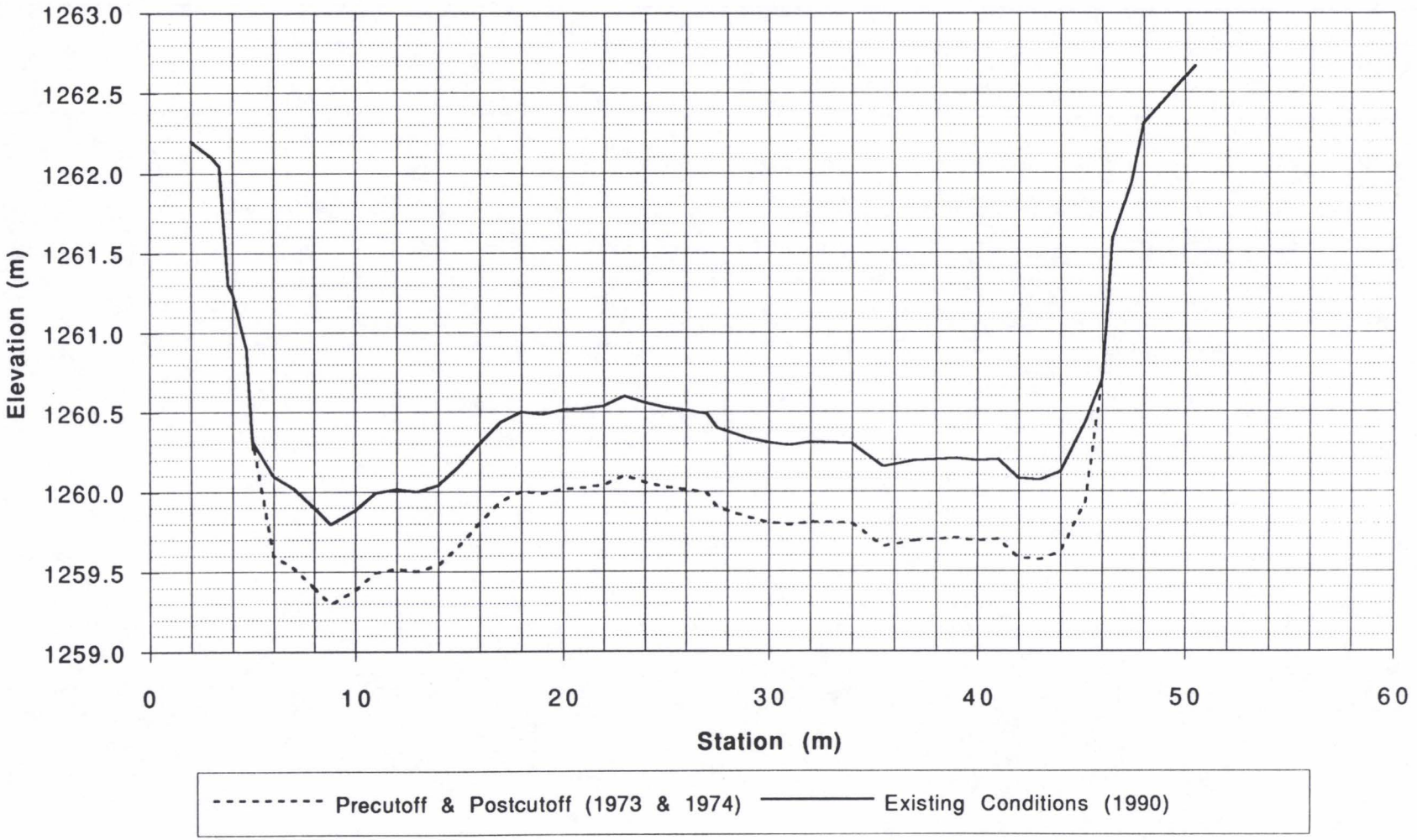


SFSR Cross Section 19

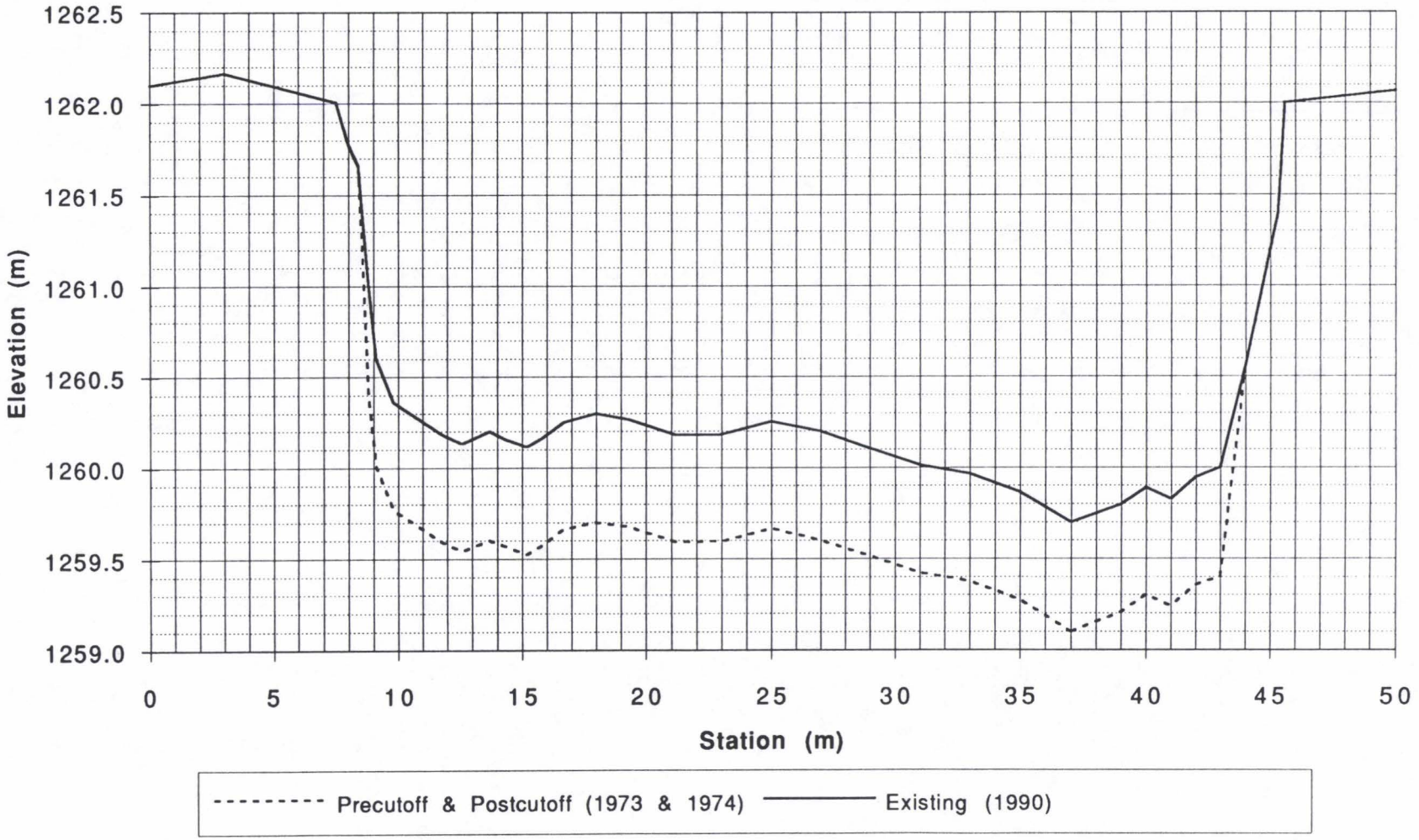



SFSR Cross Section 20
Elevation (m)
1263.5
1263.0
1262.5
1262.0
1261.5
1261.0
1260.5
1260.0
1259.5
1259.0
0
5
10
15
20
25
30
35
40
Station (m)
All scenarios

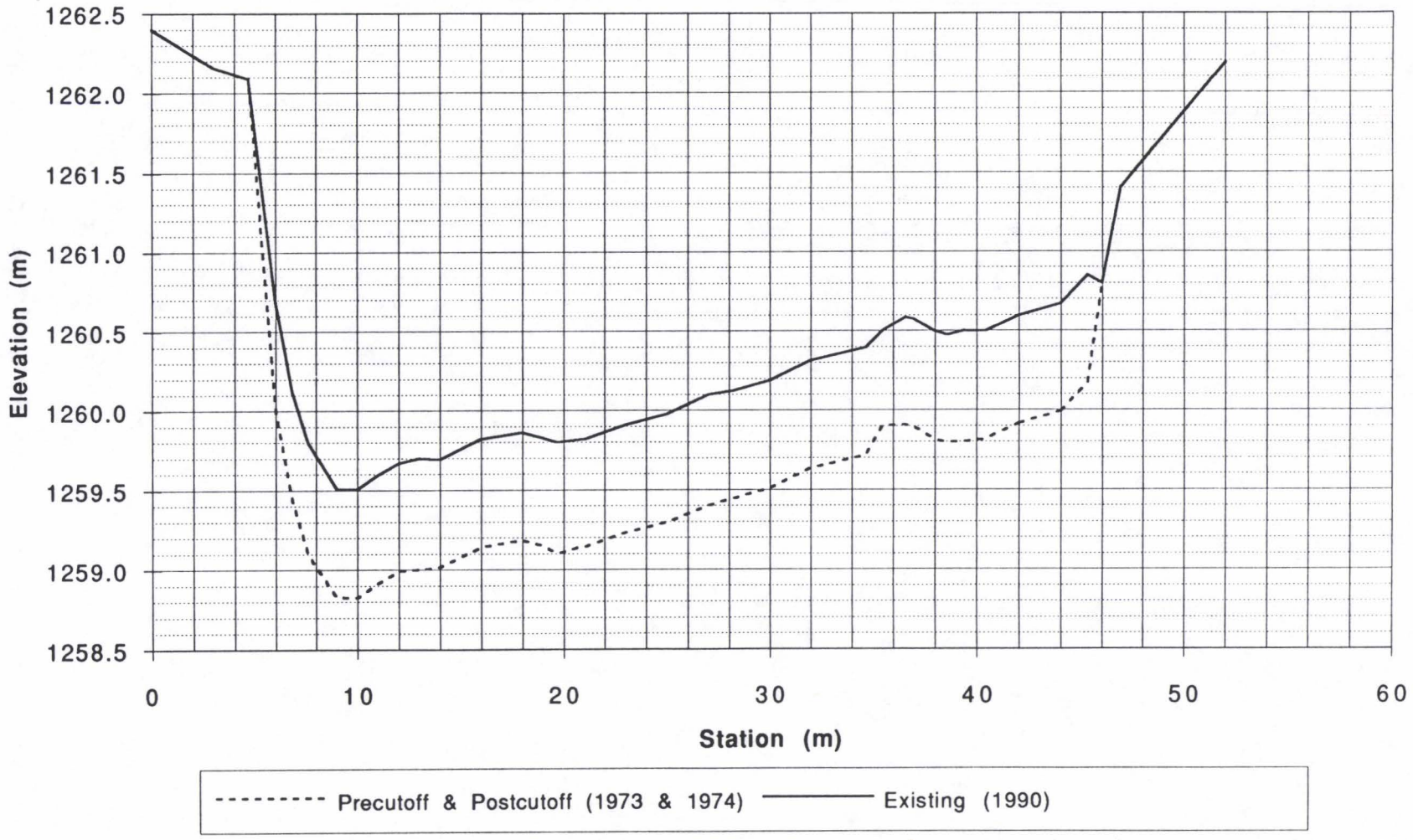
SFSR Cross Section 21



SFSR Cross Section 22



SFSR Cross Section 23



APPENDIX B.

SEDIMENT GRAIN SIZE DATA

WEIGHT				Bot Bucket	Bot Bucket	Bot Bucket	Bot Bucket	Bot Bucket	Shovel	Shovel	Shovel	Shovel	Shovel	Shovel	Shovel	Shovel	Grab Bucket	Grab Bucket
Sieve	Sieve	Midpt	Midpt	2 45	6 32	19 37	21 23	22 18	7 15	8 26	9 21	9 33	11 16	13 35 top	13 35 bot	13 43	19 19	21 8.8
f	*mm*	*f*	*mm*	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)
-7.50	*181*	*-7.75*	*215*	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-7.00	*128*	*-7.25*	*152*	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-6.50	*90.5*	*-6.75*	*107.6*	2000	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-6.00	*64.0*	*-6.25*	*76.1*	2800	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	730.30	0.00
-5.50	*45.3*	*-5.75*	*53.8*	1900	983.3	2298.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1441.80	432.10
-5.00	*32.0*	*-5.25*	*38.1*	1350	1356.5	1903.90	47.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1730.50	364.00
-4.50	*22.6*	*-4.75*	*26.9*	990	634.3	1066.00	556.78	362.35	0.00	96.30	0.00	23.90	0.00	0.00	0.00	0.00	734.40	357.80
-4.00	*16.0*	*-4.25*	*19.0*	350.00	650.1	687.50	673.38	975.98	119.90	130.60	47.45	100.84	0.00	0.00	159.02	0.00	630.70	349.70
-3.50	*11.3*	*-3.75*	*13.5*	326.70	471.50	496.20	349.07	872.35	239.70	161.90	87.92	216.47	9.82	0.00	374.50	0.00	484.50	219.10
-3.00	*8.00*	*-3.25*	*9.51*	308.60	414.50	372.55	284.54	604.07	241.30	151.72	147.91	298.75	76.17	5.85	271.21	54.33	375.90	199.28
-2.50	*5.66*	*-2.75*	*6.73*	346.97	419.40	308.37	226.37	376.84	253.60	152.67	225.57	417.80	253.58	12.12	212.69	112.83	311.19	147.24
-2.00	*4.00*	*-2.25*	*4.76*	286.90	321.90	229.74	249.97	402.95	256.35	231.41	295.61	408.80	573.60	37.42	230.34	262.43	281.73	127.81
-1.50	*2.83*	*-1.75*	*3.36*	285.45	325.00	212.72	261.34	437.14	324.01	368.39	419.10	584.90	840.70	181.52	297.66	493.80	333.38	115.00
-1.00	*2.00*	*-1.25*	*2.38*	238.26	346.21	242.84	166.94	372.79	419.33	286.78	373.45	513.03	877.86	185.65	388.34	879.14	216.21	119.82
-0.50	*1.41*	*-0.75*	*1.68*	55.14	360.27	114.37	178.39	287.76	179.71	415.83	433.92	159.77	226.00	388.75	151.49	339.18	218.31	39.28
0.00	*1.00*	*-0.25*	*1.19*	57.25	309.24	188.06	148.72	295.91	302.32	380.69	321.95	244.11	237.17	380.71	236.64	426.89	160.41	51.99
0.50	*0.71*	*0.25*	*0.84*	37.15	280.21	210.45	150.28	318.58	348.92	379.84	339.20	337.89	138.52	354.39	263.10	336.85	158.31	50.20
1.00	*0.50*	*0.75*	*0.59*	19.75	184.82	166.07	154.62	316.77	488.34	340.48	315.10	440.10	70.98	639.23	257.10	273.91	133.56	42.31
1.50	*0.35*	*1.25*	*0.42*	13.03	131.99	133.76	161.04	313.32	572.77	259.23	266.21	376.09	52.76	257.97	250.49	315.00	120.69	46.17
2.00	*0.25*	*1.75*	*0.30*	10.73	72.49	76.38	158.44	244.06	324.74	129.05	114.80	203.68	58.60	184.81	211.43	343.26	73.14	37.16
2.50	*0.18*	*2.25*	*0.21*	7.52	33.18	37.20	81.04	117.68	102.99	39.64	36.85	77.40	55.51	56.53	103.34	176.00	25.59	15.19
2.75	*0.15*	*2.63*	*0.16*	3.06	8.66	13.08	24.64	43.88	30.83	10.40	8.50	21.58	23.37	10.25	26.25	46.33	6.85	3.55
Pan	*Pan*	*3.00*	*0.13*	5.92	26.15	39.25	66.64	102.26	38.89	26.99	33.78	45.90	47.78	21.06	34.10	88.00	20.14	4.15
			Sum	11392.42	7329.71	8797.03	3939.60	6444.69	4243.70	3561.92	3467.31	4471.01	3542.41	2716.26	3467.71	4147.96	8187.62	2721.85
			Ø mean	-5.25	-3.30	-4.06	-2.27	-1.98	-0.61	-0.94	-0.82	-1.04	-1.27	0.13	-1.12	-0.32	-4.05	-3.64
			mm mean	37.99	9.88	16.70	4.81	3.94	1.53	1.93	1.77	2.05	2.40	0.91	2.18	1.25	16.54	12.49
			St. Dev Ø	1.59	2.17	2.04	2.25	2.14	1.86	1.75	1.54	1.78	1.23	1.10	1.95	1.49	2.06	1.96
			St. Dev (geo	3.01	4.50	4.11	4.74	4.41	3.64	3.37	2.90	3.43	2.35	2.14	3.87	2.80	4.16	3.89
			D90	110.0	50.0	56.0	26.0	20.0	10.0	12.0	7.0	10.0	5.7	2.6	12.0	4.0	52.0	51.0
			D84	94.0	44.0	51.0	23.0	18.0	7.0	8.0	5.3	7.3	5.0	2.0	11.0	3.4	56.0	44.0
			D65	70.0	28.0	38.0	16.0	12.0	2.7	3.0	2.8	3.7	3.5	1.3	4.2	2.3	39.0	27.0
			D50	54.0	16.0	30.0	7.5	5.5	1.3	1.7	1.8	2.5	2.8	0.9	2.4	1.6	30.0	18.0
			D35	37.00	6.50	18.00	3.20	2.50	0.50	1.10	1.20	1.20	2.30	0.61	0.66	0.86	17.0	11.0
			D16	14.00	1.60	4.00	0.70	0.60	0.40	0.55	0.55	0.50	1.30	0.44	0.46	0.37	3.3	3.0

PERCENT

Sieve	Sieve	Midpt	Midpt	Bot Bucket	Bot Bucket	Bot Bucket	Bot Bucket	Bot Bucket	Shovel	Shovel	Shovel	Shovel	Shovel	Shovel	Shovel	Shovel	Grab Bucket	Grab Bucket
f	*mm*	*f*	*mm*	2 45	6 32	19 37	21 23	22 18	7 15	8 26	9 21	9 33	11 16	13 35 top	13 35 bot	13 43	19 19	21 8.8
-7.50	*181*	*-7.75*	*215*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-7.00	*128*	*-7.25*	*152*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-6.50	*90.5*	*-6.75*	*107.6*	17.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-6.00	*64.0*	*-6.25*	*76.1*	24.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.92	0.00
-5.50	*45.3*	*-5.75*	*53.8*	16.68	13.42	26.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.61	15.88
-5.00	*32.0*	*-5.25*	*38.1*	11.85	18.51	21.64	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.14	13.37
-4.50	*22.6*	*-4.75*	*26.9*	8.69	8.65	12.12	14.13	5.62	0.00	2.70	0.00	0.53	0.00	0.00	0.00	0.00	8.97	13.15
-4.00	*16.0*	*-4.25*	*19.0*	3.07	8.87	7.82	17.09	15.14	2.83	3.67	1.37	2.26	0.00	0.00	4.59	0.00	7.70	12.85
-3.50	*11.3*	*-3.75*	*13.5*	2.87	6.43	5.64	8.86	13.54	5.65	4.55	2.54	4.84	0.28	0.00	10.80	0.00	5.92	8.05
-3.00	*8.00*	*-3.25*	*9.51*	2.71	5.66	4.23	7.22	9.37	5.69	4.26	4.27	6.68	2.15	0.22	7.82	1.31	4.59	7.32
-2.50	*5.66*	*-2.75*	*6.73*	3.05	5.72	3.51	5.75	5.85	5.98	4.29	6.51	9.34	7.16	0.45	6.13	2.72	3.80	5.41
-2.00	*4.00*	*-2.25*	*4.76*	2.52	4.39	2.61	6.35	6.25	6.04	6.50	8.53	9.14	16.19	1.38	6.64	6.33	3.44	4.70
-1.50	*2.83*	*-1.75*	*3.36*	2.51	4.43	2.42	6.63	6.78	7.64	10.34	12.09	13.08	23.73	6.68	8.58	11.90	4.07	4.23
-1.00	*2.00*	*-1.25*	*2.38*	2.09	4.72	2.76	4.24	5.78	9.88	8.05	10.77	11.47	24.78	6.83	11.20	21.19	2.64	4.40
-0.50	*1.41*	*-0.75*	*1.68*	0.48	4.92	1.30	4.53	4.46	4.23	11.67	12.51	3.57	6.38	14.31	4.37	8.18	2.67	1.44
0.00	*1.00*	*-0.25*	*1.19*	0.50	4.22	2.14	3.77	4.59	7.12	10.69	9.29	5.46	6.70	14.02	6.82	10.29	1.96	1.91
0.50	*0.71*	*0.25*	*0.84*	0.33	3.82	2.39	3.81	4.94	8.22	10.66	9.78	7.56	3.91	13.05	7.59	8.12	1.93	1.84
1.00	*0.50*	*0.75*	*0.59*	0.17	2.52	1.89	3.92	4.92	11.51	9.56	9.09	9.84	2.00	23.53	7.41	6.60	1.63	1.55
1.50	*0.35*	*1.25*	*0.42*	0.11	1.80	1.52	4.09	4.86	13.50	7.28	7.68	8.41	1.49	9.50	7.22	7.59	1.47	1.70
2.00	*0.25*	*1.75*	*0.30*	0.09	0.99	0.87	4.02	3.79	7.65	3.62	3.31	4.56	1.65	6.80	6.10	8.28	0.89	1.37
2.50	*0.18*	*2.25*	*0.21*	0.07	0.45	0.42	2.06	1.83	2.43	1.11	1.06	1.73	1.57	2.08	2.98	4.24	0.31	0.56
2.75	*0.15*	*2.63*	*0.16*	0.03	0.12	0.15	0.63	0.68	0.73	0.29	0.25	0.48	0.66	0.38	0.76	1.12	0.08	0.13
Pan	*Pan*	*3.00*	*0.13*	0.05	0.36	0.45	1.69	1.59	0.92	0.76	0.97	1.03	1.35	0.78	0.98	2.12	0.25	0.15
			SUM	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

CUMULATIVE PERCENT

Sieve	Sieve	Midpt	Midpt	Bot Bucket	Bot Bucket	Bot Bucket	Bot Bucket	Bot Bucket	Shovel	Shovel	Shovel	Shovel	Shovel	Shovel	Shovel	Shovel	Grab Bucket	Grab Bucket
f	*mm*	*f*	*mm*	2 45	6 32	19 37	21 23	22 18	7 15	8 26	9 21	9 33	11 16	13 35 top	13 35 bot	13 43	19 19	21 8.8
-7.50	*181*	*-7.75*	*215*	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
-7.00	*128*	*-7.25*	*152*	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
-6.50	*90.5*	*-6.75*	*107.6*	82.44	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
-6.00	*64.0*	*-6.25*	*76.1*	57.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.08	100.00
-5.50	*45.3*	*-5.75*	*53.8*	41.19	86.58	73.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	73.47	84.12
-5.00	*32.0*	*-5.25*	*38.1*	29.34	68.08	52.23	98.80	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	52.34	70.75
-4.50	*22.6*	*-4.75*	*26.9*	20.65	59.42	40.11	84.66	94.38	100.00	97.30	100.00	99.47	100.00	100.00	100.00	100.00	43.37	57.61
-4.00	*16.0*	*-4.25*	*19.0*	17.58	50.55	32.30	67.57	79.23	97.17	93.63	98.63	97.21	100.00	100.00	95.41	100.00	35.66	44.76
-3.50	*11.3*	*-3.75*	*13.5*	14.71	44.12	26.66	58.71	65.70	91.53	89.08	96.10	92.37	99.72	100.00	84.61	100.00	29.75	36.71
-3.00	*8.00*	*-3.25*	*9.51*	12.00	38.47	22.42	51.49	56.32	85.84	84.83	91.83	85.69	97.57	99.78	76.79	98.69	25.15	29.39
-2.50	*5.66*	*-2.75*	*6.73*	8.95	32.74	18.91	45.74	50.48	79.86	80.54	85.32	76.34	90.41	99.34	70.66	95.97	21.35	23.98
-2.00	*4.00*	*-2.25*	*4.76*	6.44	28.35	16.30	39.40	44.22	73.82	74.04	76.80	67.20	74.22	97.96	64.02	89.64	17.91	19.28
-1.50	*2.83*	*-1.75*	*3.36*	3.93	23.92	13.89	32.76	37.44	66.19	63.70	64.71	54.12	50.49	91.28	55.43	77.74	13.84	15.06
-1.00	*2.00*	*-1.25*	*2.38*	1.84	19.20	11.12	28.53	31.66	56.31	55.65	53.94	42.64	25.71	84.44	44.24	56.54	11.20	10.65
-0.50	*1.41*	*-0.75*	*1.68*	1.36	14.28	9.82	24.00	27.19	52.07	43.97	41.43	39.07	19.33	70.13	39.87	48.37	8.53	9.21
0.00	*1.00*	*-0.25*	*1.19*	0.85	10.06	7.69	20.22	22.60	44.95	33.29	32.14	33.61	12.63	56.12	33.04	38.08	6.57	7.30
0.50	*0.71*	*0.25*	*0.84*	0.53	6.24	5.29	16.41	17.66	36.73	22.62	22.36	26.05	8.72	43.07	25.46	29.95	4.64	5.46
1.00	*0.50*	*0.75*	*0.59*	0.35	3.72	3.41	12.48	12.74	25.22	13.06	13.27	16.21	6.72	19.53	18.04	23.35	3.01	3.90
1.50	*0.35*	*1.25*	*0.42*	0.24	1.92	1.89	8.40	7.88	11.72	5.79	5.59	7.80	5.23	10.04	10.82	15.76	1.54	2.21
2.00	*0.25*	*1.75*	*0.30*	0.14	0.93	1.02	4.37	4.09	4.07	2.16	2.28	3.24	3.58	3.23	4.72	7.48	0.64	0.84
2.50	*0.18*	*2.25*	*0.21*	0.08	0.47	0.59	2.32	2.27	1.64	1.05	1.22	1.51	2.01	1.15	1.74	3.24	0.33	0.28
2.75	*0.15*	*2.63*	*0.16*	0.05	0.36	0.45	1.69	1.59	0.92	0.76	0.97	1.03	1.35	0.78	0.98	2.12	0.25	0.15
Pan	*0.10*	*3.00*	*0.13*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

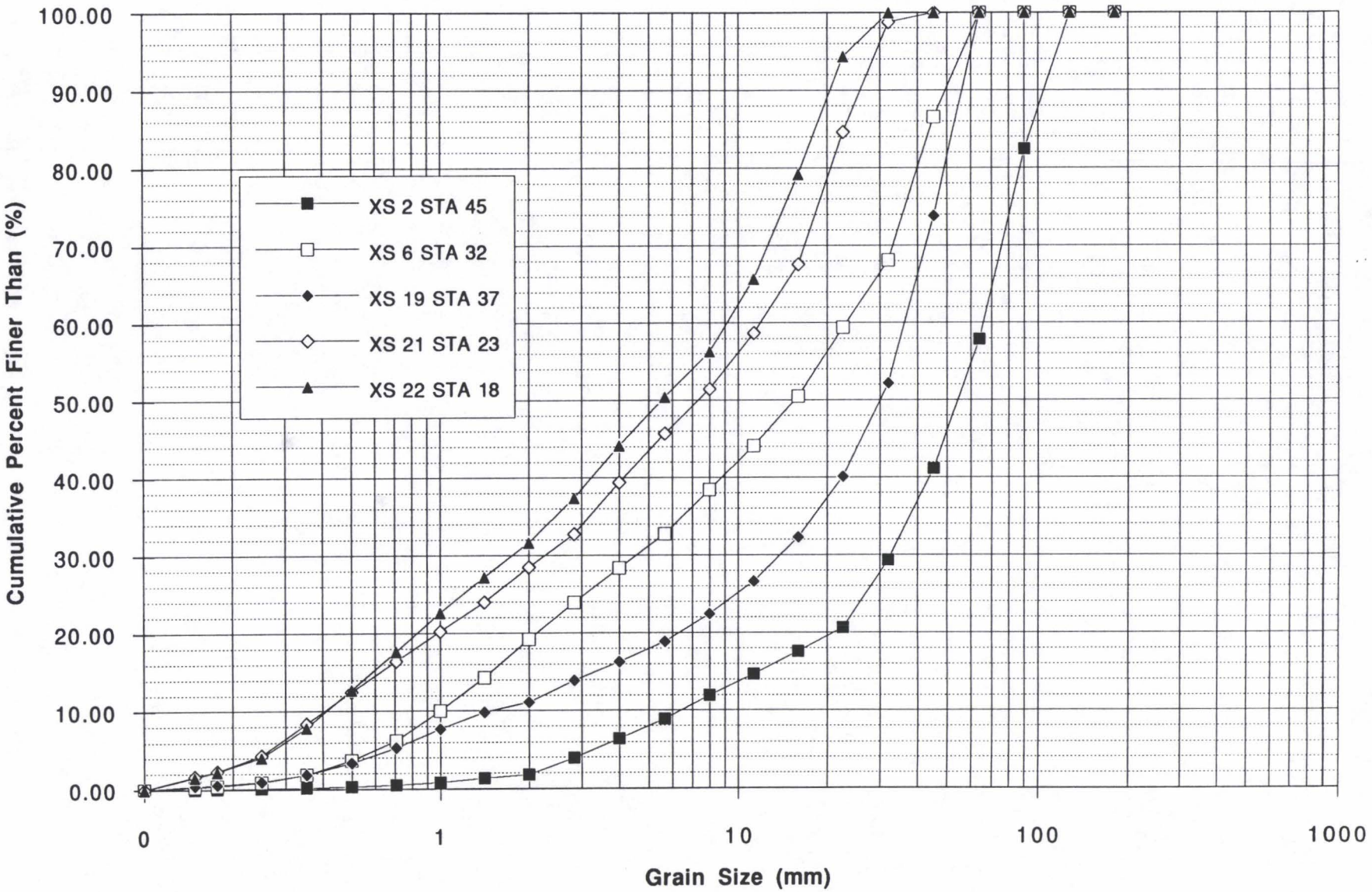
NUMBER				Pebble	Pebble	Pebble	Pebble	Pebble
Sieve	Sieve	Midpt	Midpt	6 16-40	7 22-28	19 24-37	19 37-50	22 18
f	*mm*	*f*	*mm*	(#)	(#)	(#)	(#)	(#)
-8.00	*256*	*-8.25*	*304*	0	0	0	0	0
-7.50	*181*	*-7.75*	*215*	0	9	0	0	0
-7.00	*128*	*-7.25*	*152*	0	6	0	0	0
-6.50	*90.5*	*-6.75*	*107.6*	6	7	4	0	0
-6.00	*64.0*	*-6.25*	*76.1*	7	1	17	3	0
-5.50	*45.3*	*-5.75*	*53.8*	14	8	23	16	0
-5.00	*32.0*	*-5.25*	*38.1*	16	12	34	19	1
-4.50	*22.6*	*-4.75*	*26.9*	5	7	15	18	15
-4.00	*16.0*	*-4.25*	*19.0*	4	2	5	13	16
-3.50	*11.3*	*-3.75*	*13.5*	0	1	3	12	10
-3.00	*8.00*	*-3.25*	*9.51*	0	0	1	2	6
-2.00	*4.00*	*-2.25*	*4.76*	2	0	3	3	9
-1.00	*2.00*	*-1.25*	*2.38*	1	0	0	1	5
	<2.00	*0.00*	*1.00*	5	8	1	11	4
			Sum	60	61	106	98	66
			Ø mean	-4.92	-5.27	-5.26	-4.19	-3.45
			mm mean	30.29	38.49	38.37	18.27	10.96
			St. Dev Ø	1.80	2.31	1.00	1.74	1.37
			St. Dev (geo	3.48	4.96	2.00	3.33	2.59
			D90	90	200	80	56	28
			D84	75	180	70	49	26
			D65	53	95	50	35	19
			D50	43	46	41	27	16
			D35	34.00	34.00	34.00	18.00	11.00
			D16	18.00	18.00	26.00	9.00	0.45

PERCENT Sieve	Sieve	Midpt	Midpt	Pebble	Pebble	Pebble	Pebble	Pebble
f	*mm*	*f*	*mm*	6 16-40	7 22-28	19 24-37	19 37-50	22 18
-8.00	*256*	*-8.25*	*304*	0.00	0.00	0.00	0.00	0.00
-7.50	*181*	*-7.75*	*215*	0.00	14.75	0.00	0.00	0.00
-7.00	*128*	*-7.25*	*152*	0.00	9.84	0.00	0.00	0.00
-6.50	*90.5*	*-6.75*	*107.6*	10.00	11.48	3.77	0.00	0.00
-6.00	*64.0*	*-6.25*	*76.1*	11.67	1.64	16.04	3.06	0.00
-5.50	*45.3*	*-5.75*	*53.8*	23.33	13.11	21.70	16.33	0.00
-5.00	*32.0*	*-5.25*	*38.1*	26.67	19.67	32.08	19.39	1.52
-4.50	*22.6*	*-4.75*	*26.9*	8.33	11.48	14.15	18.37	22.73
-4.00	*16.0*	*-4.25*	*19.0*	6.67	3.28	4.72	13.27	24.24
-3.50	*11.3*	*-3.75*	*13.5*	0.00	1.64	2.83	12.24	15.15
-3.00	*8.00*	*-3.25*	*9.51*	0.00	0.00	0.94	2.04	9.09
-2.00	*4.00*	*-2.25*	*4.76*	3.33	0.00	2.83	3.06	13.64
-1.00	*2.00*	*-1.25*	*2.38*	1.67	0.00	0.00	1.02	7.58
	<2.00	*0.25*	*0.84*	8.33	13.11	0.94	11.22	6.06
			SUM	100.00	100.00	100.00	100.00	100.00

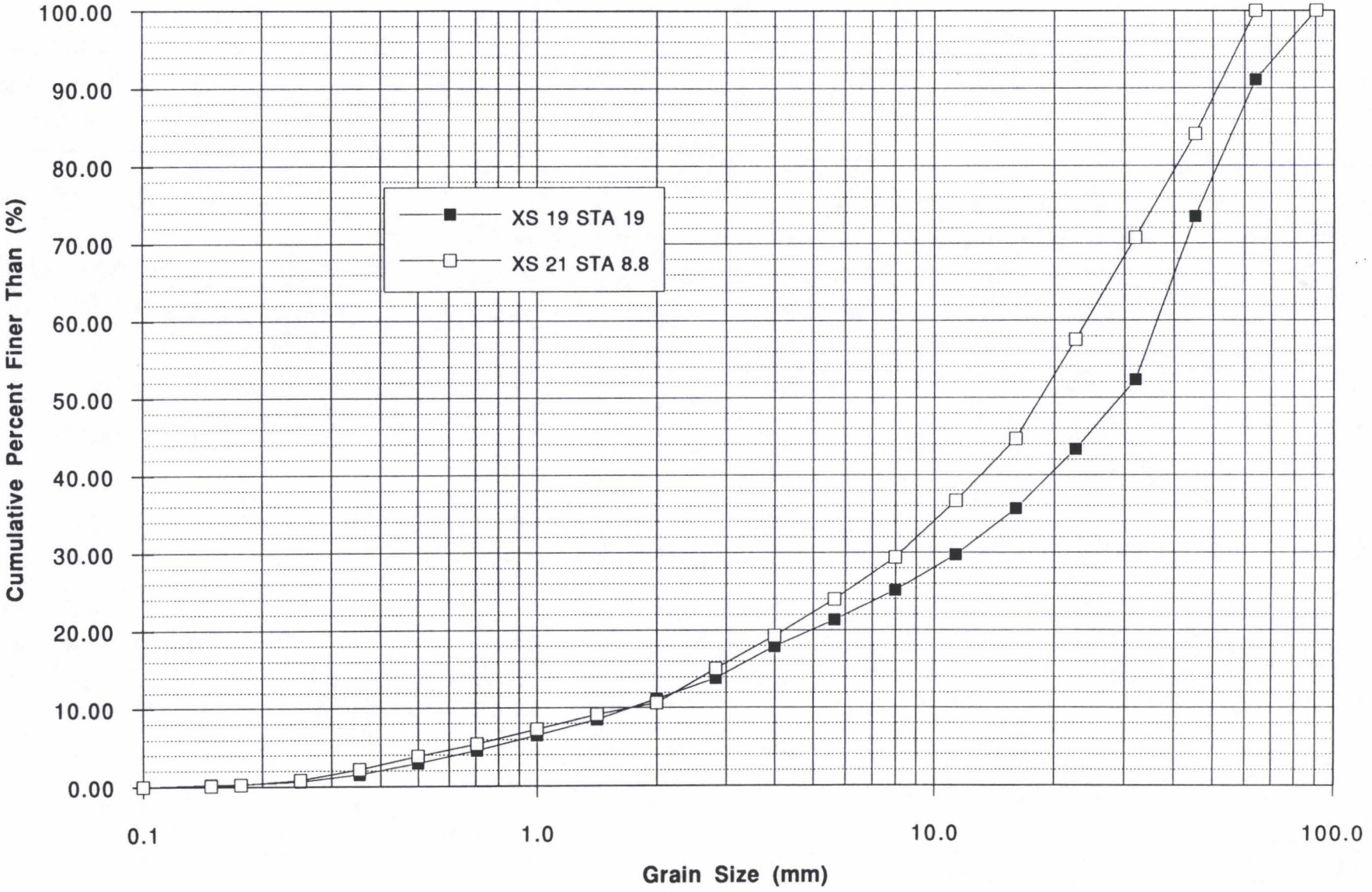
JLATIVE PERCENT

Sieve	Sieve	Midpt	Midpt	Pebble	Pebble	Pebble	Pebble	Pebble
f	*mm*	*f*	*mm*	6 16-40	7 22-28	19 24-37	19 37-50	22 18
-8.00	*256*	*-8.25*	*304*	100.00	100.00	100.00	100.00	100.00
-7.50	*181*	*-7.75*	*215*	100.00	85.25	100.00	100.00	100.00
-7.00	*128*	*-7.25*	*152*	100.00	75.41	100.00	100.00	100.00
-6.50	*90.5*	*-6.75*	*107.6*	90.00	63.93	96.23	100.00	100.00
-6.00	*64.0*	*-6.25*	*76.1*	78.33	62.30	80.19	96.94	100.00
-5.50	*45.3*	*-5.75*	*53.8*	55.00	49.18	58.49	80.61	100.00
-5.00	*32.0*	*-5.25*	*38.1*	28.33	29.51	26.42	61.22	98.48
-4.50	*22.6*	*-4.75*	*26.9*	20.00	18.03	12.26	42.86	75.76
-4.00	*16.0*	*-4.25*	*19.0*	13.33	14.75	7.55	29.59	51.52
-3.50	*11.3*	*-3.75*	*13.5*	13.33	13.11	4.72	17.35	36.36
-3.00	*8.00*	*-3.25*	*9.51*	13.33	13.11	3.77	15.31	27.27
-2.00	*4.00*	*-2.25*	*4.76*	10.00	13.11	0.94	12.24	13.64
-1.00	*2.00*	*-1.25*	*2.38*	8.33	13.11	0.94	11.22	6.06
Pan	*1.00*	*0.00*	*1.00*	0.00	0.00	0.00	0.00	0.00

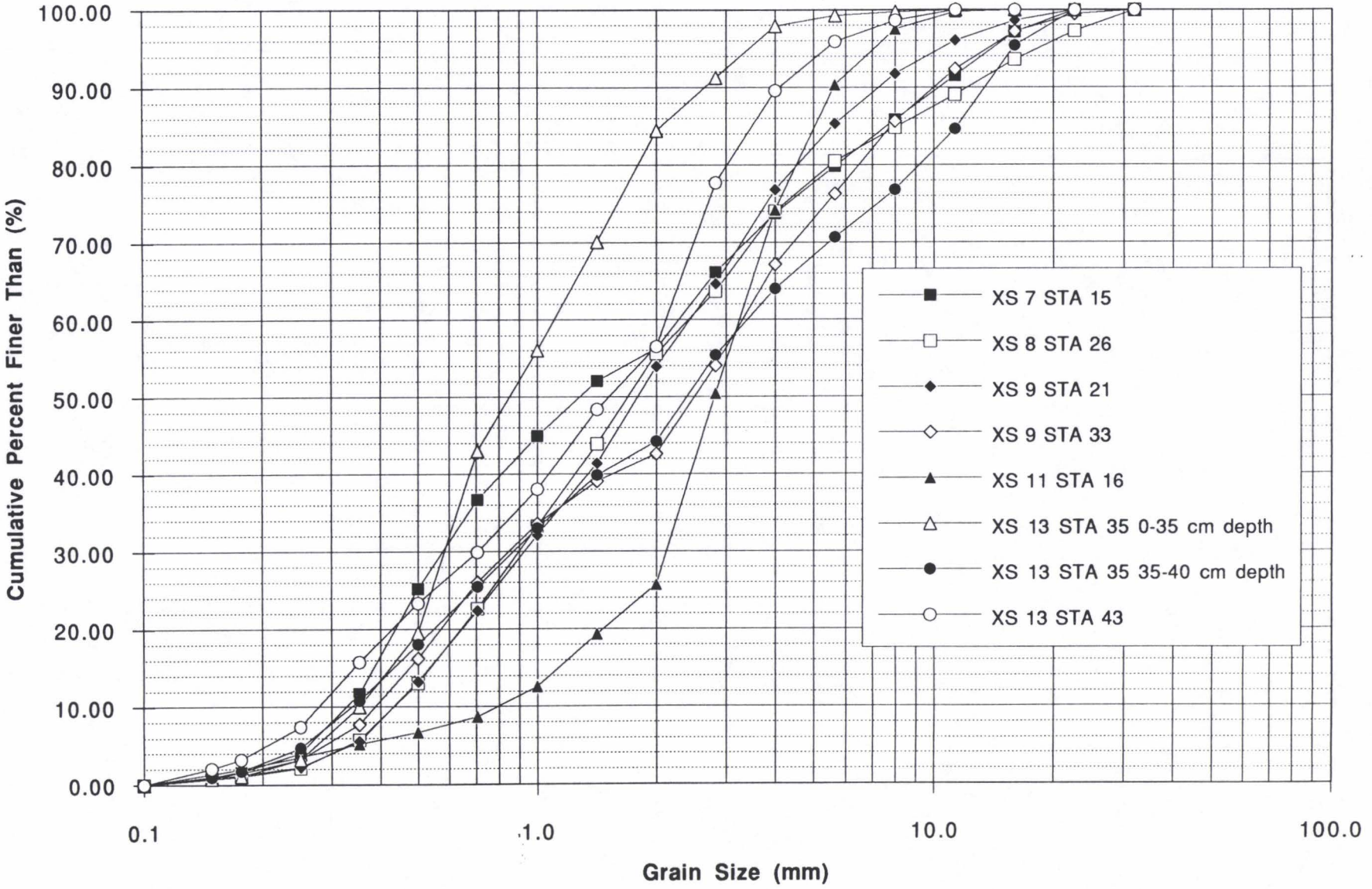
SFSR Bottomless Bucket Bulk Sediment Samples



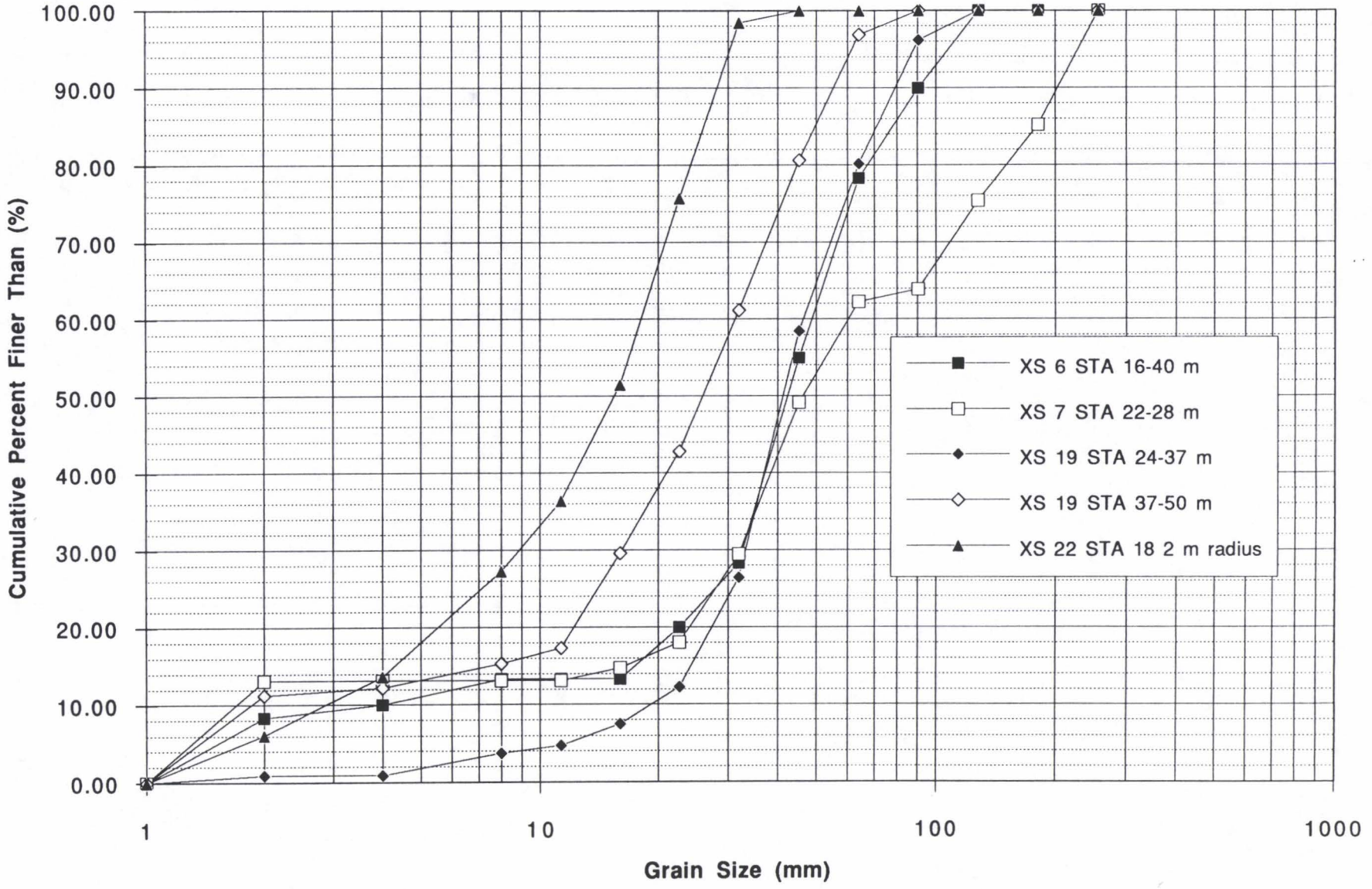
SFSR Grab Bucket Bulk Sediment Samples



SFSR Shovel Bulk Sediment Samples



SFSR Pebble Count Sediment Samples



APPENDIX C.

HEC-2 INPUT FILES

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T1       SOUTH FORK SALMON RIVER OXBOW AND CUTOFF NEAR MCCALL, IDAHO
T1
T2       CROSS SECTIONS SURVEYED BY ALAN BARTA AND BRIAN McARDELL OCTOBER 1990
T2       CROSS SECTIONS 10.1 & 10.2 SURVEYED MAY 1991 BY ALAN BARTA
T2
T2       DESANDED CROSS SECTIONS DEVELOPED BY ALAN BARTA AUGUST/SEPT.1991
T2       HEC-2 INPUT DECK ASSEMBLED AUGUST/SEPT. 1991 BY CONOR SHEA, P.E.
T2
T2       FINAL GEOMETRY NOVEMBER 1991
T3       SIMULATED PRE-CUTOFF CONDITIONS - OXBOW DEPOSITION REMOVED
J1   -10       2       0       0   0.001       1    .167       0 1260.91       0
J2     0       0      -1       0       0       0
J6     1
*        Default Contraction and Expansion Coefficients Assigned
*        Overbank Roughness Assigned by NC Cards
*        Channel Roughness Assigned by NV Cards
QT     8   2.832   7.080   14.16   28.32   56.64   84.96  113.28  141.60
NC 0.025   0.025   0.030     0.1     0.3
NV     4   0.035  1250.0   0.035 1259.45   0.030 1260.11   0.030 1400.00
*        Reach Lengths Initially Assumed Identical for Channel and Overbanks
*        Section 23 Lowered 68 cm
X1    23      38    4.70   46.90     0.0     0.0     0.0
GR1262.4    0.001262.156    3.001262.090    4.701260.003    6.001259.452    6.80
GR1259.1    7.601258.828    9.001258.825   10.001258.913   11.001258.989   12.00
GR1259.0   13.001259.013   14.001259.141   16.001259.182   18.001259.150   19.00
GR1259.1   19.701259.138   20.801259.140   21.001259.230   23.001259.297   25.00
GR1259.4   27.001259.444   28.201259.510   30.001259.634   32.001259.717   34.70
GR1259.9   35.501259.906   36.601259.895   37.001259.816   38.001259.794   38.60
GR1259.8   39.401259.816   40.401259.916   42.001259.991   44.001260.172   45.30
GR1260.8   46.001261.401   46.901262.188   52.03
NV     4   0.035  1250.0   0.035 1259.58   0.030 1260.23   0.030 1400.00
*        Section 22 Lowered 59 cm
X1    22      35    7.50   45.30    50.0    50.0    50.0
GR1262.1    0.001262.164    3.001262.006    7.501261.776    8.001261.658    8.40
GR1260.4    8.801260.010    9.101259.771    9.801259.592   11.801259.543   12.60
GR1259.6   13.701259.570   14.301259.524   15.201259.571   15.801259.663   16.70
GR1259.7   18.001259.676   19.301259.591   21.201259.595   23.001259.666   25.00
GR1259.6   27.001259.515   29.001259.424   31.001259.375   33.001259.275   35.00
GR1259.1   37.001259.206   39.001259.300   40.001259.238   41.001259.355   42.00
GR1259.4   43.001260.555   44.001261.393   45.301262.000   45.601262.066   50.00
NV     4   0.035  1250.0   0.035 1259.81   0.030 1260.40   0.030 1400.00
*        Section 21 Lowered 50 cm
X1    21      50    3.40   46.50    75.0    75.0    75.0
GR1262.2    2.001262.101    3.001262.043    3.401261.301    3.801261.250    4.00
GR1260.9    4.701260.267    5.001260.313    5.001259.598    6.001259.521    7.00
GR1259.4    8.001259.296    8.801259.382   10.001259.493   11.001259.517   12.00
GR1259.5   13.001259.540   14.001259.656   15.001259.806   16.001259.935   17.00
GR1260.0   18.001259.986   19.001260.014   20.001260.023   21.001260.040   22.00
GR1260.1   23.001260.058   24.001260.027   25.001260.013   26.001259.990   27.00
GR1259.9   27.501259.837   29.001259.807   30.001259.790   31.001259.810   32.00
GR1259.8   34.001259.657   35.501259.692   37.001259.707   39.001259.692   40.00
GR1259.7   41.001259.580   42.001259.572   43.001259.620   44.001259.930   45.20
GR1260.7   46.001261.589   46.501261.933   47.401262.309   48.001262.668   50.50
NV     4   0.060 1250.00   0.060 1260.43   0.027 1260.92   0.027 1400.00
X1    20      43    4.00   34.50    75.0    75.0    75.0
GR1261.7    0.001261.505    1.001261.136    2.001261.058    4.001260.735    5.00
GR1260.5    5.801260.424    6.001260.259    7.001260.158    8.001260.061    8.40
GR1260.0    9.001259.977   10.001259.931   11.001259.848   12.001259.748   13.00
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GR1259.7   14.001259.588   15.001259.451   16.001259.370   17.001259.292   18.00
GR1259.3   19.001259.342   20.001259.318   20.301259.740   21.601259.726   22.00
GR1259.7   23.001259.650   23.901259.722   24.301259.670   25.001259.717   26.00
GR1259.8   27.001259.959   28.001260.289   29.001260.425   29.401260.513   30.00
GR1260.8   31.001261.286   31.501261.602   32.001262.051   33.001262.287   33.90
GR1262.8   34.501263.151   35.501263.298   36.90
NV     4   0.045  1250.0   0.045 1260.02   0.027 1260.60   0.027 1400.00
*       Section 19 Lowered 40 cm
X1    19      57    4.50   57.00   120.0   120.0   120.0
GR1262.6    0.001262.571    2.001262.360    3.001262.358    4.001262.270    4.50
GR1260.8    4.701260.268    5.501260.020    6.101259.937    6.401259.900    7.00
GR1259.8    8.001259.670    9.001259.621   10.001259.651   11.001259.750   12.00
GR1259.8   12.801259.847   13.001259.805   13.501259.740   14.001259.630   15.00
GR1259.5   15.701259.513   16.001259.525   17.001259.545   18.001259.585   19.00
GR1259.6   20.001259.677   21.001259.685   21.201259.743   21.501259.700   21.90
GR1259.7   22.001259.846   23.001259.982   24.001260.021   24.201260.153   25.00
GR1260.3   27.001260.418   29.001260.512   31.001260.616   33.001260.720   35.00
GR1260.8   37.001260.853   39.001260.855   41.001260.866   43.001260.841   45.00
GR1260.9   47.001260.827   49.001260.743   50.701260.480   51.601260.258   52.50
GR1260.1   53.101260.088   53.401260.193   54.001260.631   56.001261.453   57.00
GR1263.6   59.001263.628   60.83
*       Start of Oxbow
NC 0.035   0.035   0.025     0.6     0.8
X1    13      56    2.50   51.00    41.0    41.0    41.0
GR1262.5    1.001262.394    3.501261.397    4.501260.114    5.501260.026    6.00
GR1259.8    7.001259.673    8.001259.606    9.001259.637   10.001259.667   11.00
GR1259.8   12.001259.978   13.001260.096   14.001260.148   15.001260.199   16.00
GR1260.2   17.001260.200   17.501260.200   18.001260.201   19.001260.192   20.00
GR1260.1   21.001260.058   22.001259.991   23.001259.932   24.001259.936   25.00
GR1259.9   26.001259.859   27.001259.757   28.001259.783   29.001259.841   30.00
GR1259.8   32.001259.818   33.001259.811   34.001259.823   35.001259.841   36.00
GR1259.9   37.001259.902   38.001259.934   39.001260.032   40.001260.050   41.00
GR1260.0   42.001260.025   43.001260.029   44.001259.993   45.001259.947   46.00
GR1259.9   47.001259.894   48.001260.133   49.001260.439   50.001261.349   51.00
GR1261.6   51.701261.971   52.001262.119   52.401262.230   53.001262.475   54.00
GR1262.8   55.24
X1    12      30    3.90   43.70   136.0   136.0   136.0
GR1262.6    0.001262.273    3.901261.396    4.701261.140    5.501260.918    6.20
GR1260.7    7.001260.443    7.701260.234    9.001260.061   10.701259.895   12.00
GR1260.0   14.001260.307   16.001260.424   18.001260.362   19.001260.300   20.00
GR1260.2   22.001260.088   24.001260.028   26.001260.017   28.001260.091   30.00
GR1260.1   32.001260.079   33.301260.060   35.001260.124   36.001260.253   38.00
GR1260.4   40.001260.814   42.001261.287   42.801262.411   43.701262.588   44.93
X1    11      36    1.00   41.00   105.0   105.0   105.0
GR1263.5    1.001263.033    2.001262.435    4.001261.869    6.001261.452    6.70
GR1261.0    6.901260.930    7.151260.770    7.901260.695    8.601260.653    9.00
GR1260.6   10.001260.503   11.001260.435   12.001260.472   14.001260.534   16.00
GR1260.6   18.001260.546   20.001260.508   22.001260.460   24.001260.409   26.00
GR1260.3   28.001260.242   30.001260.149   31.101260.072   32.001260.000   33.00
GR1260.1   34.001260.234   35.001260.274   36.001260.310   38.001260.328   39.00
GR1261.3   40.001261.618   41.001261.977   42.001262.145   42.301262.640   42.50
GR1262.8   43.12
X1  10.2      20    4.00   35.80   102.0   102.0   102.0
GR1263.9    0.001263.246    2.501262.535    4.001261.574    7.001261.206    8.20
GR1260.7    9.001260.517   10.001260.290   11.701260.170   13.501259.904   17.50
GR1259.8   19.701259.706   23.001259.839   26.001260.314   27.701260.583   29.00
GR1260.9   31.501261.194   33.001261.774   34.501262.371   35.801263.787   36.60
X1  10.1      25    4.60   37.50    49.0    49.0    49.0
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GR1264.5    0.001264.030    2.301262.655    4.601262.285    7.601261.822    9.50
GR1261.6   13.501261.219   16.501261.065   17.701260.783   19.001260.696   20.20
GR1260.6   21.801260.444   23.301260.319   24.501260.178   25.701260.373   27.50
GR1260.4   28.701260.381   30.501260.371   32.501260.596   34.101261.445   34.60
GR1261.9   34.901262.236   37.501262.112   46.001262.572   48.501262.659   50.90
X1    10      40    4.40   31.00    89.0    89.0    89.0
GR1262.8    1.001262.821    4.001262.509    4.301262.178    5.401261.298    5.70
GR1261.1    6.101260.811    6.501260.716    7.001260.558    8.001260.489    9.00
GR1260.4   10.001260.370   11.001260.339   12.001260.372   13.001260.404   14.00
GR1260.4   15.001260.369   17.001260.362   19.001260.502   20.701260.609   22.00
GR1260.7   23.001260.773   24.001260.921   25.801261.051   26.801261.471   28.10
GR1261.8   29.001262.085   30.001262.324   31.001262.454   32.001262.454   33.00
GR1262.6   35.001262.554   37.001262.525   39.001262.488   39.801262.652   41.00
GR1262.8   43.001262.869   45.001262.931   47.001263.069   49.001263.228   52.40
X1     9      38    2.30   30.00   140.0   140.0   140.0
GR1262.6    2.601261.917    3.301261.333    4.001261.081    4.601260.858    5.50
GR1260.7    6.001260.610    6.501260.524    7.001260.564    8.001260.592    8.70
GR1260.6    9.401260.645   10.001260.646   10.401260.644   10.601260.642   10.85
GR1260.6   11.201260.632   12.201260.626   13.001260.525   14.001260.251   15.00
GR1259.7   17.001260.033   19.001260.488   21.001260.879   23.001261.189   25.00
GR1261.5   27.001261.655   28.001261.810   29.001261.923   30.001262.001   31.00
GR1262.0   33.001262.035   35.001262.047   37.001262.067   39.001262.073   41.00
GR1262.1   42.301262.833   43.501262.955   45.10
X1     8      38    4.00   38.70   102.0   102.0   102.0
GR1262.9    1.001262.674    4.501262.316    5.001261.885    6.001261.664    7.00
GR1261.4    8.001261.223    9.001261.002   10.001260.781   11.001260.560   12.00
GR1260.6   13.001260.735   14.001260.938   16.001260.960   17.001260.944   18.00
GR1260.9   19.001260.911   20.001260.894   21.001260.880   22.001260.907   23.00
GR1260.9   24.001260.963   25.001260.991   26.001260.964   27.001260.936   28.00
GR1260.9   29.001260.880   30.001260.863   30.801260.896   32.001260.923   33.00
GR1261.0   34.001260.998   35.001261.040   35.701261.110   37.001261.153   38.00
GR1261.4   39.001262.194   39.701262.665   41.60
*       Upstream End of Oxbow
X1     7      37    4.00   31.00    51.0    51.0    51.0
GR1263.4    1.001263.280    2.801262.757    3.401262.170    5.001262.086    6.00
GR1262.0    7.001261.917    8.001261.832    9.001261.748   10.001261.663   11.00
GR1261.6   12.001261.495   13.001261.426   14.001261.434   15.001261.442   16.00
GR1261.5   17.001261.458   18.001261.406   19.001261.334   20.001261.261   21.00
GR1261.2   21.301261.171   22.101261.007   23.001261.027   24.001261.086   25.00
GR1261.0   26.001261.156   27.001261.174   27.401261.449   28.001261.531   29.00
GR1261.8   30.001261.985   31.001262.124   32.001262.310   33.001262.512   34.00
GR1262.9   35.001263.284   36.20
*       Cross Section 6 raised 21 cm from 1990 survey
NC 0.035   0.035   0.035     0.1     0.3
NV     4   0.057  1250.0   0.057 1261.52   0.033 1262.01   0.033 1400.00
X1     6      32    7.40   50.00    93.0    93.0    93.0
GR1263.3    1.001263.373    7.401263.152    7.601262.976    8.001262.325    8.50
GR1262.0   10.601261.911   12.001261.793   14.001261.545   16.101261.427   17.00
GR1261.3   18.001261.215   20.001261.199   22.001261.196   24.001261.225   26.00
GR1261.3   28.001261.269   30.001261.365   32.001261.389   34.001261.374   36.00
GR1261.5   38.001261.513   38.701261.574   39.501261.488   40.201261.347   41.00
GR1261.3   41.601261.497   43.401261.605   43.801261.733   44.001261.935   45.10
GR1262.5   46.001263.046   50.001263.179   58.00
NV     4   0.045  1250.0   0.045 1261.61   0.030 1262.04   0.030 1400.00
*       Cross Section 5 raised 15 cm from 1990 survey
X1     5      34    3.00   44.00    49.0    49.0    49.0
GR1263.7    1.001263.641    3.001263.161    3.201262.626    4.101262.573    4.70
GR1262.2    5.001261.896    6.501261.772    8.001261.618    9.301261.521   10.00
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GR1261.4   12.001261.331   14.001261.314   16.001261.188   17.601261.170   18.00
GR1261.2   20.001261.315   22.001261.398   24.001261.499   26.001261.518   28.00
GR1261.4   30.001261.464   32.001261.554   33.601261.598   34.601261.764   35.20
GR1262.0   37.001261.598   38.901261.478   40.001261.605   41.501261.863   42.80
GR1262.4   43.701263.026   44.001263.195   45.001263.120   48.55
NV     4   0.045  1250.0   0.045 1261.70   0.030 1262.11   0.030 1400.00
*       Cross Section 4 raised 14 cm from 1990 survey
X1     4       40    3.70   41.00    36.0    36.0    36.0
GR1264.0    1.001263.961    3.401263.303    3.701262.545    4.601262.097    5.40
GR1261.7    6.401261.629    7.101261.529    8.001261.481   10.001261.468   10.60
GR1261.5   12.001261.586   13.701261.646   14.501261.647   16.001261.572   18.00
GR1261.5   20.001261.518   22.001261.505   23.001261.423   24.001261.459   25.00
GR1261.4   26.001261.390   27.001261.525   28.001261.542   29.001261.571   30.00
GR1261.6   31.001261.526   32.001261.500   33.001261.619   34.001261.499   35.10
GR1261.5   36.001261.564   37.001261.561   38.001261.678   39.001261.703   39.40
GR1262.6   39.801262.865   40.201263.201   41.001263.193   43.801263.663   43.80
NV     4   0.090  1250.0   0.090 1261.74   0.035 1262.06   0.035 1400.00
X1     3       35    5.40   44.80    27.0    27.0    27.0
GR1264.2    1.001264.070    2.301263.506    3.201263.120    5.401262.150    6.10
GR1261.7    7.401261.634    7.901261.660    8.401261.729    9.701261.761   10.90
GR1261.8   12.801261.703   13.501261.605   15.001261.598   17.001261.601   18.00
GR1261.5   21.001261.519   23.001261.421   25.001261.296   26.501261.270   27.00
GR1261.3   29.001261.218   30.001261.230   31.001261.245   33.001261.331   35.00
GR1261.4   37.001261.492   39.001261.437   40.001261.443   41.001261.673   43.00
GR1261.8   43.501262.285   43.901262.663   44.501263.261   44.801263.332   46.55
NV     4   0.060  1250.0   0.060 1261.94   0.035 1262.28   0.035 1400.00
X1     2       31    2.50   50.45    82.0    82.0    82.0
GR1264.3    1.001264.223    2.501262.640    3.501262.221    4.401261.831    6.00
GR1261.6    7.001261.483    9.501261.536   11.101261.551   15.201261.851   16.70
GR1261.8   19.001261.666   22.001261.766   25.001261.829   28.001261.788   32.00
GR1261.7   33.601261.701   36.001261.668   38.001261.766   39.101261.786   40.20
GR1261.8   41.401261.916   42.601261.898   44.301261.896   45.401261.929   47.20
GR1262.2   48.201262.686   48.701262.826   49.301263.391   49.601263.656   50.45
GR1263.7   55.00
NV     4   0.070  1250.0   0.070 1261.09   0.025 1262.47   0.025 1400.00
X1     1       19    3.90   48.00   125.0   125.0   125.0
GR1264.0    1.001263.891    3.901263.308    5.801262.897    9.501262.378   11.20
GR1262.1   16.701261.912   18.601261.947   20.201261.787   25.001261.732   28.00
GR1261.6   31.001261.699   35.001261.782   39.001262.082   43.001262.445   45.30
GR1262.8   46.301263.510   46.701263.785   48.001263.971   49.90
EJ
T1
T2
T3       SIMULATED PRE-CUTOFF CONDITIONS - OXBOW DEPOSITION REMOVED
J1   -10       3       0       0   0.001       1    .167       0 1260.19
J2     2       0      -1       0       0       0
T1
T2
T3       SIMULATED PRE-CUTOFF CONDITIONS - OXBOW DEPOSITION REMOVED
J1   -10       4       0       0   0.001       1    .167       0 1260.19
J2     3       0      -1       0       0       0
T1
T2
T3       SIMULATED PRE-CUTOFF CONDITIONS - OXBOW DEPOSITION REMOVED
J1   -10       5       0       0   0.001       1    .167       0 1260.19
J2     4       0      -1       0       0       0
T1
T2
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T3      SIMULATED PRE-CUTOFF CONDITIONS - OXBOW DEPOSITION REMOVED
J1   -10       6       0       0   0.001       1    .167       0 1260.19
J2     5       0      -1       0       0       0
T1
T2
T3      SIMULATED PRE-CUTOFF CONDITIONS - OXBOW DEPOSITION REMOVED
J1   -10       7       0       0   0.001       1    .167       0 1260.19
J2     6       0      -1       0       0       0
T1
T2
T3      SIMULATED PRE-CUTOFF CONDITIONS - OXBOW DEPOSITION REMOVED
J1   -10       8       0       0   0.001       1    .167       0 1260.19
J2     7       0      -1       0       0       0
T1
T2
T3      SIMULATED PRE-CUTOFF CONDITIONS - OXBOW DEPOSITION REMOVED
J1   -10       9       0       0   0.001       1    .167       0 1260.19
J2    15       0      -1       0       0       0
ER
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T1       SOUTH FORK SALMON RIVER OXBOW AND CUTOFF NEAR MCCALL, IDAHO
T1
T2       CROSS SECTIONS SURVEYED BY ALAN BARTA AND BRIAN McARDELL OCTOBER 1990
T2       CROSS SECTIONS 10.1 & 10.2 SURVEYED MAY 1991 BY ALAN BARTA
T2
T2       DESANDED CROSS SECTIONS DEVELOPED BY ALAN BARTA AUGUST/SEPT.1991
T2       HEC-2 INPUT DECK ASSEMBLED AUGUST/SEPT. 1991 BY CONOR SHEA, P.E.
T2
T2       FINAL GEOMETRY NOVEMBER 1991
T2       SIMULATED IMMEDIATE POST CUTOFF (1974):
T2              FIRST PASS AT BREACH FIT 0.36m (SECTIONS 14,15,16,17,18)
T2              BREACH CROSS SECTION WIDTHS FROM 1974 AERIAL PHOTOS
T2              - (14:11 m, 15:9 m, 16:8 m, 17:5 m, 18:12 m)
T2              CROSS SECTIONS 4,5,6 RAISED TO PRE-CUTOFF ELEVATIONS
T2              CROSS SECTIONS 7,8,9,10,10.1,10.2,11,12,13 DESANDED
T2              CROSS SECTIONS 19,21,22,23 ADJUSTED TO PRE-CUTOFF DEPTHS
T2
T2       MEASURED FLOW SPLIT COMPUTATIONS
T3
J1   -10       2       0       0   0.001       1    .167       0 1260.91       0
J2     0       0      -1       0       0       0
J6     1
*        Default Contraction and Expansion Coefficients Assigned
*        Overbank Roughness Assigned by NC Cards
*        Channel Roughness Assigned by NV Cards
QT     8   2.832   7.080   14.16   28.32   56.64   84.96  113.28  141.60
NC 0.025   0.025   0.030     0.1     0.3
NV     4   0.035  1250.0   0.035 1259.45   0.030 1260.11   0.030 1400.00
*        Reach Lengths Initially Assumed Identical for Channel and Overbanks
*        Section 23 Lowered 68 cm
X1    23      38    4.70   46.90     0.0     0.0     0.0
GR1262.4    0.001262.156    3.001262.090    4.701260.003    6.001259.452    6.80
GR1259.1    7.601258.828    9.001258.825   10.001258.913   11.001258.989   12.00
GR1259.0   13.001259.013   14.001259.141   16.001259.182   18.001259.150   19.00
GR1259.1   19.701259.138   20.801259.140   21.001259.230   23.001259.297   25.00
GR1259.4   27.001259.444   28.201259.510   30.001259.634   32.001259.717   34.70
GR1259.9   35.501259.906   36.601259.895   37.001259.816   38.001259.794   38.60
GR1259.8   39.401259.816   40.401259.916   42.001259.991   44.001260.172   45.30
GR1260.8   46.001261.401   46.901262.188   52.03
NV     4   0.035  1250.0   0.035 1259.58   0.030 1260.23   0.030 1400.00
*        Section 22 Lowered 59 cm
X1    22      35    7.50   45.30    50.0    50.0    50.0
GR1262.1    0.001262.164    3.001262.006    7.501261.776    8.001261.658    8.40
GR1260.4    8.801260.010    9.101259.771    9.801259.592   11.801259.543   12.60
GR1259.6   13.701259.570   14.301259.524   15.201259.571   15.801259.663   16.70
GR1259.7   18.001259.676   19.301259.591   21.201259.595   23.001259.666   25.00
GR1259.6   27.001259.515   29.001259.424   31.001259.375   33.001259.275   35.00
GR1259.1   37.001259.206   39.001259.300   40.001259.238   41.001259.355   42.00
GR1259.4   43.001260.555   44.001261.393   45.301262.000   45.601262.066   50.00
NV     4   0.035  1250.0   0.035 1259.81   0.030 1260.40   0.030 1400.00
*        Section 21 Lowered 50 cm
X1    21      50    3.40   46.50    75.0    75.0    75.0
GR1262.2    2.001262.101    3.001262.043    3.401261.301    3.801261.250    4.00
GR1260.9    4.701260.267    5.001260.313    5.001259.598    6.001259.521    7.00
GR1259.4    8.001259.296    8.801259.382   10.001259.493   11.001259.517   12.00
GR1259.5   13.001259.540   14.001259.656   15.001259.806   16.001259.935   17.00
GR1260.0   18.001259.986   19.001260.014   20.001260.023   21.001260.040   22.00
GR1260.1   23.001260.058   24.001260.027   25.001260.013   26.001259.990   27.00
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GR1259.9   27.501259.837   29.001259.807   30.001259.790   31.001259.810   32.00
GR1259.8   34.001259.657   35.501259.692   37.001259.707   39.001259.692   40.00
GR1259.7   41.001259.580   42.001259.572   43.001259.620   44.001259.930   45.20
GR1260.7   46.001261.589   46.501261.933   47.401262.309   48.001262.668   50.50
NV     4   0.060 1250.00   0.060 1260.43   0.027 1260.92   0.027 1400.00
X1    20      43    4.00   34.50    75.0    75.0    75.0
GR1261.7    0.001261.505    1.001261.136    2.001261.058    4.001260.735    5.00
GR1260.5    5.801260.424    6.001260.259    7.001260.158    8.001260.061    8.40
GR1260.0    9.001259.977   10.001259.931   11.001259.848   12.001259.748   13.00
GR1259.7   14.001259.588   15.001259.451   16.001259.370   17.001259.292   18.00
GR1259.3   19.001259.342   20.001259.318   20.301259.740   21.601259.726   22.00
GR1259.7   23.001259.650   23.901259.722   24.301259.670   25.001259.717   26.00
GR1259.8   27.001259.959   28.001260.289   29.001260.425   29.401260.513   30.00
GR1260.8   31.001261.286   31.501261.602   32.001262.051   33.001262.287   33.90
GR1262.8   34.501263.151   35.501263.298   36.90
NV     4   0.045  1250.0   0.045 1260.02   0.027 1260.60   0.027 1400.00
*       Section 19 Lowered 40 cm
X1    19      57    4.50   57.00   120.0   120.0   120.0
GR1262.6    0.001262.571    2.001262.360    3.001262.358    4.001262.270    4.50
GR1260.8    4.701260.268    5.501260.020    6.101259.937    6.401259.900    7.00
GR1259.8    8.001259.670    9.001259.621   10.001259.651   11.001259.750   12.00
GR1259.8   12.801259.847   13.001259.805   13.501259.740   14.001259.630   15.00
GR1259.5   15.701259.513   16.001259.525   17.001259.545   18.001259.585   19.00
GR1259.6   20.001259.677   21.001259.685   21.201259.743   21.501259.700   21.90
GR1259.7   22.001259.846   23.001259.982   24.001260.021   24.201260.153   25.00
GR1260.3   27.001260.418   29.001260.512   31.001260.616   33.001260.720   35.00
GR1260.8   37.001260.853   39.001260.855   41.001260.866   43.001260.841   45.00
GR1260.9   47.001260.827   49.001260.743   50.701260.480   51.601260.258   52.50
GR1260.1   53.101260.088   53.401260.193   54.001260.631   56.001261.453   57.00
GR1263.6   59.001263.628   60.83
QT     8    2.05    4.38    7.03   13.65   24.65   31.33   37.90   43.70
NC 0.050   0.050   0.050     0.3     0.5
NV     4   0.090 1250.00   0.090 1261.36   0.037 1261.88   0.037 1400.00
X1    18      22   23.16   34.75    54.0    54.0    54.0
GR1263.0    8.401261.952   10.001261.221   12.001261.000   14.001261.000   14.80
GR1261.0   16.001261.000   18.001261.000   21.031261.000   23.161259.970   25.60
GR1259.7   27.431259.160   28.651259.160   31.091259.240   32.001259.672   32.61
GR1260.4   33.531261.000   34.751261.000   35.971261.000   39.621261.000   41.00
GR1261.7   44.001263.765   46.40
NC 0.050   0.050   0.050     0.3     0.5
NV     4   0.090 1250.00   0.090 1261.06   0.037 1261.76   0.037 1400.00
X1    17      28    5.20   13.00    16.0    16.0    16.0
GR1262.8    0.001262.380    0.601262.380    1.001262.380    1.701262.380    2.20
GR1262.4    2.701262.380    3.301262.380    4.001262.380    4.701262.380    5.20
GR1262.4    6.651260.931    6.901260.803    7.201260.298    7.301260.188    7.90
GR1260.3    8.001260.058    8.701259.678    8.901259.448    9.901259.678   10.40
GR1260.5   10.801260.935   11.101260.875   12.001262.380   13.001262.380   14.00
GR1262.4   14.651262.380   15.401262.383   15.80
NV     4   0.140  1250.0   0.140 1261.18   0.045 1261.90   0.045 1400.00
X1    16      42    9.80   18.00    15.0    15.0    15.0
GR1262.5    0.001261.848    1.501261.848    3.001261.848    4.001261.848    4.70
GR1261.8    5.501261.848    6.501261.848    7.001261.848    7.201261.848    7.50
GR1261.8    8.001261.848    8.701261.848    9.001261.848    9.601261.848    9.80
GR1260.4   10.801260.272   11.901260.315   12.801260.108   14.201260.088   14.30
GR1260.1   15.001260.647   15.401260.664   16.301260.904   16.501260.945   17.00
GR1260.9   17.501261.848   18.001261.848   19.001261.848   20.001261.848   21.00
GR1261.8   22.001261.848   23.001261.848   23.701261.848   24.001261.848   24.50
GR1261.8   25.001261.848   25.101261.848   25.401261.848   25.701261.848   25.90
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GR1262.6   26.301262.697   28.85
NV     4   0.100  1250.0   0.100 1260.93   0.050 1261.46   0.050 1400.00
X1    15      36    8.00   17.00    13.0    13.0    13.0
GR1262.5    0.001261.607    1.001261.600    1.601261.600    2.601261.600    3.00
GR1261.6    4.001261.600    4.801261.600    5.001261.600    5.501261.600    6.20
GR1261.6    7.001261.600    8.001261.232    9.001261.248    9.201261.244    9.80
GR1261.2   10.001261.290   10.201261.404   11.101261.310   11.601261.200   12.80
GR1261.2   13.701260.958   15.001260.783   15.501260.908   15.701260.799   16.30
GR1261.6   17.001261.600   17.801261.600   18.501261.600   18.901261.600   19.20
GR1261.6   20.001261.600   21.001261.600   21.801261.600   22.301261.600   22.70
GR1262.2   23.50
*       Upstream End of Cutoff
NV     4   0.085  1250.0   0.085 1261.13   0.045 1261.65   0.045 1400.00
X1    14      33   15.00   26.30    32.0    32.0    32.0
GR1263.3    0.001262.564    3.501262.000    3.801262.000    6.801262.000    9.00
GR1262.0    9.701262.000   10.201262.000   12.001262.000   13.001262.000   14.00
GR1262.0   15.001261.187   16.001261.131   16.801261.233   17.001261.269   17.80
GR1261.1   18.401261.057   18.501261.014   19.301260.835   20.001260.804   20.60
GR1260.9   21.501260.886   22.601260.961   23.801261.022   25.001261.182   26.00
GR1262.0   26.301262.000   27.301262.000   28.301262.004   29.001262.180   29.70
GR1262.8   30.001262.727   35.001262.902   42.45
*       Upstream Junction of Oxbow and Cutoff - Oxbow Flow Added to Section 6
QT     8   2.832   7.080   14.16   28.32   56.64   84.96  113.28  141.60
*       Cross Section 6 raised 21 cm from 1990 survey
NC 0.050   0.050   0.040     0.6     0.8
NV     4   0.057  1250.0   0.057 1261.52   0.033 1262.01   0.033 1400.00
X1     6      32    7.40   50.00    47.0    47.0    47.0
GR1263.3    1.001263.373    7.401263.152    7.601262.976    8.001262.325    8.50
GR1262.0   10.601261.911   12.001261.793   14.001261.545   16.101261.427   17.00
GR1261.3   18.001261.215   20.001261.199   22.001261.196   24.001261.225   26.00
GR1261.3   28.001261.269   30.001261.365   32.001261.389   34.001261.374   36.00
GR1261.5   38.001261.513   38.701261.574   39.501261.488   40.201261.347   41.00
GR1261.3   41.601261.497   43.401261.605   43.801261.733   44.001261.935   45.10
GR1262.5   46.001263.046   50.001263.179   58.00
NC 0.035   0.035   0.035     0.1     0.3
NV     4   0.045  1250.0   0.045 1261.61   0.030 1262.04   0.030 1400.00
*       Cross Section 5 raised 15 cm from 1990 survey
X1     5      34    3.00   44.00    49.0    49.0    49.0
GR1263.7    1.001263.641    3.001263.161    3.201262.626    4.101262.573    4.70
GR1262.2    5.001261.896    6.501261.772    8.001261.618    9.301261.521   10.00
GR1261.4   12.001261.331   14.001261.314   16.001261.188   17.601261.170   18.00
GR1261.2   20.001261.315   22.001261.398   24.001261.499   26.001261.518   28.00
GR1261.4   30.001261.464   32.001261.554   33.601261.598   34.601261.764   35.20
GR1262.0   37.001261.598   38.901261.478   40.001261.605   41.501261.863   42.80
GR1262.4   43.701263.026   44.001263.195   45.001263.120   48.55
NV     4   0.045  1250.0   0.045 1261.70   0.030 1262.11   0.030 1400.00
*       Cross Section 4 raised 14 cm from 1990 survey
X1     4      40    3.70   41.00    36.0    36.0    36.0
GR1264.0    1.001263.961    3.401263.303    3.701262.545    4.601262.097    5.40
GR1261.7    6.401261.629    7.101261.529    8.001261.481   10.001261.468   10.60
GR1261.5   12.001261.586   13.701261.646   14.501261.647   16.001261.572   18.00
GR1261.5   20.001261.518   22.001261.505   23.001261.423   24.001261.459   25.00
GR1261.4   26.001261.390   27.001261.525   28.001261.542   29.001261.571   30.00
GR1261.6   31.001261.526   32.001261.500   33.001261.619   34.001261.499   35.10
GR1261.5   36.001261.564   37.001261.561   38.001261.678   39.001261.703   39.40
GR1262.6   39.801262.865   40.201263.201   41.001263.193   43.801263.663   43.80
NV     4   0.090  1250.0   0.090 1261.74   0.035 1262.06   0.035 1400.00
X1     3      35    5.40   44.80    27.0    27.0    27.0
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GR1264.2    1.001264.070    2.301263.506    3.201263.120    5.401262.150    6.10
GR1261.7    7.401261.634    7.901261.660    8.401261.729    9.701261.761   10.90
GR1261.8   12.801261.703   13.501261.605   15.001261.598   17.001261.601   18.00
GR1261.5   21.001261.519   23.001261.421   25.001261.296   26.501261.270   27.00
GR1261.3   29.001261.218   30.001261.230   31.001261.245   33.001261.331   35.00
GR1261.4   37.001261.492   39.001261.437   40.001261.443   41.001261.673   43.00
GR1261.8   43.501262.285   43.901262.663   44.501263.261   44.801263.332   46.55
NV     4   0.060  1250.0   0.060 1261.94   0.035 1262.28   0.035 1400.00
X1     2      31    2.50   50.45    82.0    82.0    82.0
GR1264.3    1.001264.223    2.501262.640    3.501262.221    4.401261.831    6.00
GR1261.6    7.001261.483    9.501261.536   11.101261.551   15.201261.851   16.70
GR1261.8   19.001261.666   22.001261.766   25.001261.829   28.001261.788   32.00
GR1261.7   33.601261.701   36.001261.668   38.001261.766   39.101261.786   40.20
GR1261.8   41.401261.916   42.601261.898   44.301261.896   45.401261.929   47.20
GR1262.2   48.201262.686   48.701262.826   49.301263.391   49.601263.656   50.45
GR1263.7   55.00
NV     4   0.070  1250.0   0.070 1261.09   0.025 1262.47   0.025 1400.00
X1     1      19    3.90   48.00   125.0   125.0   125.0
GR1264.0    1.001263.891    3.901263.308    5.801262.897    9.501262.378   11.20
GR1262.1   16.701261.912   18.601261.947   20.201261.787   25.001261.732   28.00
GR1261.6   31.001261.699   35.001261.782   39.001262.082   43.001262.445   45.30
GR1262.8   46.301263.510   46.701263.785   48.001263.971   49.90
*       Start of Oxbow Calculations
NC 0.100   0.100   0.040     0.6     0.8
NV     4   0.045  1250.0   0.045 1260.02   0.027 1260.60   0.027 1400.00
*       Section 19 Lowered 40 cm
X1   -19      57    4.50   57.00   120.0   120.0   120.0
GR1262.6    0.001262.571    2.001262.360    3.001262.358    4.001262.270    4.50
GR1260.8    4.701260.268    5.501260.020    6.101259.937    6.401259.900    7.00
GR1259.8    8.001259.670    9.001259.621   10.001259.651   11.001259.750   12.00
GR1259.8   12.801259.847   13.001259.805   13.501259.740   14.001259.630   15.00
GR1259.5   15.701259.513   16.001259.525   17.001259.545   18.001259.585   19.00
GR1259.6   20.001259.677   21.001259.685   21.201259.743   21.501259.700   21.90
GR1259.7   22.001259.846   23.001259.982   24.001260.021   24.201260.153   25.00
GR1260.3   27.001260.418   29.001260.512   31.001260.616   33.001260.720   35.00
GR1260.8   37.001260.853   39.001260.855   41.001260.866   43.001260.841   45.00
GR1260.9   47.001260.827   49.001260.743   50.701260.480   51.601260.258   52.50
GR1260.1   53.101260.088   53.401260.193   54.001260.631   56.001261.453   57.00
GR1263.6   59.001263.628   60.83
*  Start of Oxbow
QT     8   0.782    2.70    7.13   14.67   31.99   53.63   75.38   97.90
NC 0.035   0.035   0.025     0.6     0.8
X1    13      56    2.50   51.00    41.0    41.0    41.0
GR1262.5    1.001262.394    3.501261.397    4.501260.114    5.501260.026    6.00
GR1259.8    7.001259.673    8.001259.606    9.001259.637   10.001259.667   11.00
GR1259.8   12.001259.978   13.001260.096   14.001260.148   15.001260.199   16.00
GR1260.2   17.001260.200   17.501260.200   18.001260.201   19.001260.192   20.00
GR1260.1   21.001260.058   22.001259.991   23.001259.932   24.001259.936   25.00
GR1259.9   26.001259.859   27.001259.757   28.001259.783   29.001259.841   30.00
GR1259.8   32.001259.818   33.001259.811   34.001259.823   35.001259.841   36.00
GR1259.9   37.001259.902   38.001259.934   39.001260.032   40.001260.050   41.00
GR1260.0   42.001260.025   43.001260.029   44.001259.993   45.001259.947   46.00
GR1259.9   47.001259.894   48.001260.133   49.001260.439   50.001261.349   51.00
GR1261.6   51.701261.971   52.001262.119   52.401262.230   53.001262.475   54.00
GR1262.8   55.24
X1    12      30    3.90   43.70   136.0   136.0   136.0
GR1262.6    0.001262.273    3.901261.396    4.701261.140    5.501260.918    6.20
GR1260.7    7.001260.443    7.701260.234    9.001260.061   10.701259.895   12.00
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GR1260.0   14.001260.307   16.001260.424   18.001260.362   19.001260.300   20.00
GR1260.2   22.001260.088   24.001260.028   26.001260.017   28.001260.091   30.00
GR1260.1   32.001260.079   33.301260.060   35.001260.124   36.001260.253   38.00
GR1260.4   40.001260.814   42.001261.287   42.801262.411   43.701262.588   44.93
X1    11      36    1.00   41.00   105.0   105.0   105.0
GR1263.5    1.001263.033    2.001262.435    4.001261.869    6.001261.452    6.70
GR1261.0    6.901260.930    7.151260.770    7.901260.695    8.601260.653    9.00
GR1260.6   10.001260.503   11.001260.435   12.001260.472   14.001260.534   16.00
GR1260.6   18.001260.546   20.001260.508   22.001260.460   24.001260.409   26.00
GR1260.3   28.001260.242   30.001260.149   31.101260.072   32.001260.000   33.00
GR1260.1   34.001260.234   35.001260.274   36.001260.310   38.001260.328   39.00
GR1261.3   40.001261.618   41.001261.977   42.001262.145   42.301262.640   42.50
GR1262.8   43.12
X1  10.2      20    4.00   35.80   102.0   102.0   102.0
GR1263.9    0.001263.246    2.501262.535    4.001261.574    7.001261.206    8.20
GR1260.7    9.001260.517   10.001260.290   11.701260.170   13.501259.904   17.50
GR1259.8   19.701259.706   23.001259.839   26.001260.314   27.701260.583   29.00
GR1260.9   31.501261.194   33.001261.774   34.501262.371   35.801263.787   36.60
X1  10.1      25    4.60   37.50    49.0    49.0    49.0
GR1264.5    0.001264.030    2.301262.655    4.601262.285    7.601261.822    9.50
GR1261.6   13.501261.219   16.501261.065   17.701260.783   19.001260.696   20.20
GR1260.6   21.801260.444   23.301260.319   24.501260.178   25.701260.373   27.50
GR1260.4   28.701260.381   30.501260.371   32.501260.596   34.101261.445   34.60
GR1261.9   34.901262.236   37.501262.112   46.001262.572   48.501262.659   50.90
X1    10      40    4.40   31.00    89.0    89.0    89.0
GR1262.8    1.001262.821    4.001262.509    4.301262.178    5.401261.298    5.70
GR1261.1    6.101260.811    6.501260.716    7.001260.558    8.001260.489    9.00
GR1260.4   10.001260.370   11.001260.339   12.001260.372   13.001260.404   14.00
GR1260.4   15.001260.369   17.001260.362   19.001260.502   20.701260.609   22.00
GR1260.7   23.001260.773   24.001260.921   25.801261.051   26.801261.471   28.10
GR1261.8   29.001262.085   30.001262.324   31.001262.454   32.001262.454   33.00
GR1262.6   35.001262.554   37.001262.525   39.001262.488   39.801262.652   41.00
GR1262.8   43.001262.869   45.001262.931   47.001263.069   49.001263.228   52.40
X1     9      38    2.30   30.00   140.0   140.0   140.0
GR1262.6    2.601261.917    3.301261.333    4.001261.081    4.601260.858    5.50
GR1260.7    6.001260.610    6.501260.524    7.001260.564    8.001260.592    8.70
GR1260.6    9.401260.645   10.001260.646   10.401260.644   10.601260.642   10.85
GR1260.6   11.201260.632   12.201260.626   13.001260.525   14.001260.251   15.00
GR1259.7   17.001260.033   19.001260.488   21.001260.879   23.001261.189   25.00
GR1261.5   27.001261.655   28.001261.810   29.001261.923   30.001262.001   31.00
GR1262.0   33.001262.035   35.001262.047   37.001262.067   39.001262.073   41.00
GR1262.1   42.301262.833   43.501262.955   45.10
X1     8      38    4.00   38.70   102.0   102.0   102.0
GR1262.9    1.001262.674    4.501262.316    5.001261.885    6.001261.664    7.00
GR1261.4    8.001261.223    9.001261.002   10.001260.781   11.001260.560   12.00
GR1260.6   13.001260.735   14.001260.938   16.001260.960   17.001260.944   18.00
GR1260.9   19.001260.911   20.001260.894   21.001260.880   22.001260.907   23.00
GR1260.9   24.001260.963   25.001260.991   26.001260.964   27.001260.936   28.00
GR1260.9   29.001260.880   30.001260.863   30.801260.896   32.001260.923   33.00
GR1261.0   34.001260.998   35.001261.040   35.701261.110   37.001261.153   38.00
GR1261.4   39.001262.194   39.701262.665   41.60
*       Upstream End of Oxbow
X1     7      37    4.00   31.00    51.0    51.0    51.0
GR1263.4    1.001263.280    2.801262.757    3.401262.170    5.001262.086    6.00
GR1262.0    7.001261.917    8.001261.832    9.001261.748   10.001261.663   11.00
GR1261.6   12.001261.495   13.001261.426   14.001261.434   15.001261.442   16.00
GR1261.5   17.001261.458   18.001261.406   19.001261.334   20.001261.261   21.00
GR1261.2   21.301261.171   22.101261.007   23.001261.027   24.001261.086   25.00
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GR1261.0   26.001261.156   27.001261.174   27.401261.449   28.001261.531   29.00
GR1261.8   30.001261.985   31.001262.124   32.001262.310   33.001262.512   34.00
GR1262.9   35.001263.284   36.20
*       Cross Section 6 raised 21 cm from 1990 survey
QT     8   2.832   7.080   14.16   28.32   56.64   84.96  113.28  141.60
NV     4   0.057  1250.0   0.057 1261.52   0.033 1262.01   0.033 1400.00
X1    96      32    7.40   50.00    93.0    93.0    93.0
GR1263.3    1.001263.373    7.401263.152    7.601262.976    8.001262.325    8.50
GR1262.0   10.601261.911   12.001261.793   14.001261.545   16.101261.427   17.00
GR1261.3   18.001261.215   20.001261.199   22.001261.196   24.001261.225   26.00
GR1261.3   28.001261.269   30.001261.365   32.001261.389   34.001261.374   36.00
GR1261.5   38.001261.513   38.701261.574   39.501261.488   40.201261.347   41.00
GR1261.3   41.601261.497   43.401261.605   43.801261.733   44.001261.935   45.10
GR1262.5   46.001263.046   50.001263.179   58.00
EJ
T1
T2
T3      IMMEDIATE POST CUTOFF CONDITIONS - OXBOW DESANDED - BREACH PARTIAL CUT
J1   -10       3       0       0   0.001       1    .167       0 1260.19
J2     2       0      -1       0       0       0
T1
T2
T3      IMMEDIATE POST CUTOFF CONDITIONS - OXBOW DESANDED - BREACH PARTIAL CUT
J1   -10       4       0       0   0.001       1    .167       0 1260.19
J2     3       0      -1       0       0       0
T1
T2
T3      IMMEDIATE POST CUTOFF CONDITIONS - OXBOW DESANDED - BREACH PARTIAL CUT
J1   -10       5       0       0   0.001       1    .167       0 1260.19
J2     4       0      -1       0       0       0
T1
T2
T3      IMMEDIATE POST CUTOFF CONDITIONS - OXBOW DESANDED - BREACH PARTIAL CUT
J1   -10       6       0       0   0.001       1    .167       0 1260.19
J2     5       0      -1       0       0       0
T1
T2
T3      IMMEDIATE POST CUTOFF CONDITIONS - OXBOW DESANDED - BREACH PARTIAL CUT
J1   -10       7       0       0   0.001       1    .167       0 1260.19
J2     6       0      -1       0       0       0
T1
T2
T3      IMMEDIATE POST CUTOFF CONDITIONS - OXBOW DESANDED - BREACH PARTIAL CUT
J1   -10       8       0       0   0.001       1    .167       0 1260.19
J2     7       0      -1       0       0       0
T1
T2
T3      IMMEDIATE POST CUTOFF CONDITIONS - OXBOW DESANDED - BREACH PARTIAL CUT
J1   -10       9       0       0   0.001       1    .167       0 1260.19
J2    15       0      -1       0       0       0
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T1       SOUTH FORK SALMON RIVER OXBOW AND CUTOFF NEAR MCCALL, IDAHO
T1
T2       CROSS SECTIONS SURVEYED BY ALAN BARTA AND BRIAN McARDELL OCTOBER 1990
T2       CROSS SECTIONS 10.1 & 10.2 SURVEYED MAY 1991 BY ALAN BARTA
T2
T2       HEC-2 INPUT DECK ASSEMBLED SUMMER 1991 BY CONOR SHEA, P.E.
T2
T2       RATING CURVE RUN - FLOW SPLITS PREVIOUSLY COMPUTED
T3       DISCHARGE 2.832 CMS (100 CFS)
J1   -10       2       0       0   0.001       1    .167       0 1260.91       0
J2     0       0      -1       0       0       0
J6     1
*        Default Contraction and Expansion Coefficients Assigned
*        Overbank Roughness Assigned by NC Cards
*        Channel Roughness Assigned by NV Cards
NC 0.025   0.025   0.030     0.1     0.3
NV     4   0.035  1250.0   0.035 1260.13   0.030 1260.79   0.030 1400.00
QT     8   2.832    7.08   14.16   28.32   56.64   84.96  113.28  141.60
*        Reach Lengths Initially Assumed Identical for Channel and Overbanks
X1    23      38    4.70   46.90     0.0             0.0
GR1262.4    0.001262.156    3.001262.090    4.701260.683    6.001260.132    6.80
GR1259.8    7.601259.508    9.001259.505   10.001259.593   11.001259.669   12.00
GR1259.7   13.001259.693   14.001259.821   16.001259.862   18.001259.830   19.00
GR1259.8   19.701259.818   20.801259.820   21.001259.910   23.001259.977   25.00
GR1260.1   27.001260.124   28.201260.190   30.001260.314   32.001260.397   34.70
GR1260.5   35.501260.586   36.601260.575   37.001260.496   38.001260.474   38.60
GR1260.5   39.401260.496   40.401260.596   42.001260.671   44.001260.852   45.30
GR1260.8   46.001261.401   46.901262.188   52.03
NV     4   0.035  1250.0   0.035 1260.17   0.030 1260.82   0.030 1400.00
X1    22      35    7.50   45.30    50.0    50.0    50.0
GR1262.1    0.001262.164    3.001262.006    7.501261.776    8.001261.658    8.40
GR1261.0    8.801260.600    9.101260.361    9.801260.182   11.801260.133   12.60
GR1260.2   13.701260.160   14.301260.114   15.201260.161   15.801260.253   16.70
GR1260.3   18.001260.266   19.301260.181   21.201260.185   23.001260.256   25.00
GR1260.2   27.001260.105   29.001260.014   31.001259.965   33.001259.865   35.00
GR1259.7   37.001259.796   39.001259.890   40.001259.828   41.001259.945   42.00
GR1260.0   43.001260.555   44.001261.393   45.301262.000   45.601262.066   50.00
NV     4   0.035  1250.0   0.035 1260.31   0.030 1260.90   0.030 1400.00
X1    21      50    3.40   46.50    75.0    75.0    75.0
GR1262.2    2.001262.101    3.001262.043    3.401261.301    3.801261.250    4.00
GR1260.9    4.701260.267    5.001260.313    5.001260.098    6.001260.021    7.00
GR1259.9    8.001259.796    8.801259.882   10.001259.993   11.001260.017   12.00
GR1260.0   13.001260.040   14.001260.156   15.001260.306   16.001260.435   17.00
GR1260.5   18.001260.486   19.001260.514   20.001260.523   21.001260.540   22.00
GR1260.6   23.001260.558   24.001260.527   25.001260.513   26.001260.490   27.00
GR1260.4   27.501260.337   29.001260.307   30.001260.290   31.001260.310   32.00
GR1260.3   34.001260.157   35.501260.192   37.001260.207   39.001260.192   40.00
GR1260.2   41.001260.080   42.001260.072   43.001260.120   44.001260.430   45.20
GR1260.7   46.001261.589   46.501261.933   47.401262.309   48.001262.668   50.50
NV     4   0.060 1250.00   0.060 1260.43   0.027 1260.92   0.027 1400.00
X1    20      43    4.00   34.50    75.0    75.0    75.0
GR1261.7    0.001261.505    1.001261.136    2.001261.058    4.001260.735    5.00
GR1260.5    5.801260.424    6.001260.259    7.001260.158    8.001260.061    8.40
GR1260.0    9.001259.977   10.001259.931   11.001259.848   12.001259.748   13.00
GR1259.7   14.001259.588   15.001259.451   16.001259.370   17.001259.292   18.00
GR1259.3   19.001259.342   20.001259.318   20.301259.740   21.601259.726   22.00
GR1259.7   23.001259.650   23.901259.722   24.301259.670   25.001259.717   26.00
GR1259.8   27.001259.959   28.001260.289   29.001260.425   29.401260.513   30.00
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GR1260.8   31.001261.286   31.501261.602   32.001262.051   33.001262.287   33.90
GR1262.8   34.501263.151   35.501263.298   36.90
NV     4   0.045  1250.0   0.045 1260.42   0.027 1261.00   0.027 1400.00
X1    19      57    4.50   57.00   120.0   120.0   120.0
GR1262.6    0.001262.571    2.001262.360    3.001262.358    4.001262.270    4.50
GR1261.2    4.701260.668    5.501260.420    6.101260.337    6.401260.300    7.00
GR1260.2    8.001260.070    9.001260.021   10.001260.051   11.001260.150   12.00
GR1260.2   12.801260.247   13.001260.205   13.501260.140   14.001260.030   15.00
GR1259.9   15.701259.913   16.001259.925   17.001259.945   18.001259.985   19.00
GR1260.0   20.001260.077   21.001260.085   21.201260.143   21.501260.100   21.90
GR1260.1   22.001260.246   23.001260.382   24.001260.421   24.201260.553   25.00
GR1260.7   27.001260.818   29.001260.912   31.001261.016   33.001261.120   35.00
GR1261.2   37.001261.253   39.001261.255   41.001261.266   43.001261.241   45.00
GR1261.3   47.001261.227   49.001261.143   50.701260.880   51.601260.658   52.50
GR1260.5   53.101260.488   53.401260.593   54.001261.031   56.001261.853   57.00
GR1263.6   59.001263.628   60.83
*       Downstream End of Cutoff - Flow Divided between Cutoff and Oxbow
QT     8   2.779    6.81   13.66   27.37   53.01   75.00   95.80  116.15
NC 0.050   0.050   0.050     0.3     0.5
NV     4   0.090 1250.00   0.090 1260.50   0.037 1261.02   0.037 1400.00
X1    18      22   10.00   44.00    54.0    54.0    54.0
GR1263.0    8.401261.952   10.001261.221   12.001260.829   14.001260.484   14.80
GR1260.0   16.001259.406   18.001259.242   21.031259.176   23.161259.119   25.60
GR1258.8   27.431258.309   28.651258.309   31.091258.389   32.001258.821   32.61
GR1259.6   33.531259.741   34.751259.938   35.971260.509   39.621260.839   41.00
GR1261.7   44.001263.765   46.40
NC 0.050   0.050   0.050     0.3     0.5
NV     4   0.090 1250.00   0.090  1260.5   0.037 1261.20   0.037 1400.00
X1    17      28    0.00   15.80    16.0    16.0    16.0
GR1262.8    0.001261.973    0.601261.293    1.001261.113    1.701260.764    2.20
GR1260.6    2.701260.290    3.301260.122    4.001260.215    4.701260.971    5.50
GR1260.5    6.651260.371    6.901260.243    7.201259.738    7.301259.628    7.90
GR1259.7    8.001259.498    8.701259.118    8.901258.888    9.901259.118   10.40
GR1259.9   10.801260.375   11.101260.315   12.001260.183   13.001260.398   14.00
GR1260.6   14.651261.001   15.401262.383   15.80
NV     4   0.140  1250.0   0.140 1260.66   0.045 1261.38   0.045 1400.00
X1    16      52    0.00   28.85    15.0    15.0    15.0
GR1262.5    0.001262.468    1.501260.983    3.001260.768    4.001260.600    4.70
GR1260.5    5.501260.290    6.501260.353    7.001259.769    7.201259.678    7.50
GR1259.6    8.001260.051    8.301259.503    8.701259.488    9.001259.889    9.60
GR1259.9    9.801260.226   10.101260.305   10.401260.032   10.451259.948   10.80
GR1260.4   11.101260.240   11.301260.328   11.801259.788   11.901259.972   12.40
GR1259.8   12.801260.121   13.301260.522   13.601260.089   14.001259.624   14.20
GR1259.6   14.301259.593   15.001260.163   15.401260.180   16.301260.420   16.50
GR1260.5   17.001260.564   18.001260.602   19.001260.562   20.001260.560   21.00
GR1260.6   22.001260.496   23.001260.655   23.701260.743   24.001260.995   24.50
GR1261.2   25.001261.591   25.101261.841   25.401261.780   25.701261.803   25.90
GR1262.6   26.301262.697   28.85
NV     4   0.100  1250.0   0.100 1261.21   0.050 1261.74   0.050 1400.00
X1    15      36    0.00   23.50    13.0    13.0    13.0
GR1262.5    0.001261.607    1.001261.199    1.601260.936    2.601260.925    3.00
GR1260.9    4.001260.893    4.801260.844    5.001260.865    5.501260.924    6.20
GR1261.0    7.001260.969    8.001260.954    9.001260.970    9.201260.966    9.80
GR1260.9   10.001261.012   10.201261.126   11.101261.032   11.601260.922   12.80
GR1260.9   13.701260.680   15.001260.505   15.501260.630   15.701260.521   16.30
GR1260.5   17.001260.446   17.801260.444   18.501260.423   18.901260.581   19.20
GR1260.6   20.001260.708   21.001260.721   21.801260.851   22.301260.974   22.70
GR1262.2   23.50
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*       Upstream End of Cutoff
NV     4   0.085  1250.0   0.085 1261.41   0.045 1261.93   0.045 1400.00
X1    14      34    3.50   30.00    32.0    32.0    32.0
GR1263.3    0.001262.564    3.501261.483    3.801261.147    6.801260.968    9.00
GR1260.9    9.701260.783   10.201260.732   12.001260.785   13.001261.032   14.00
GR1261.0   15.001260.909   16.001260.853   16.801260.955   17.001260.991   17.80
GR1260.8   18.401260.779   18.501260.736   19.301260.557   20.001260.526   20.60
GR1260.6   21.501260.608   22.601260.683   23.801260.744   25.001260.904   26.00
GR1260.8   26.301260.961   27.301261.016   28.301262.004   29.001262.180   29.70
GR1262.8   30.001262.727   35.001262.902   42.451263.052   42.45
*       Upstream Junction of Oxbow and Cutoff - Oxbow Flow Added to Section 6
QT     8   2.832    7.08   14.16   28.32   56.64   84.96  113.28  141.60
NC 0.050   0.050   0.040     0.6     0.8
NV     4   0.057  1250.0   0.057 1261.31   0.033 1261.80   0.033 1400.00
X1     6      32    7.40   50.00    47.0    47.0    47.0
GR1263.3    1.001263.373    7.401263.152    7.601262.976    8.001262.325    8.50
GR1261.7   10.601261.701   12.001261.583   14.001261.335   16.101261.217   17.00
GR1261.1   18.001261.005   20.001260.989   22.001260.986   24.001261.015   26.00
GR1261.1   28.001261.059   30.001261.155   32.001261.179   34.001261.164   36.00
GR1261.3   38.001261.303   38.701261.364   39.501261.278   40.201261.137   41.00
GR1261.1   41.601261.287   43.401261.395   43.801261.733   44.001261.935   45.10
GR1262.5   46.001263.046   50.00
NC 0.050   0.050   0.035     0.1     0.3
NV     4   0.045  1250.0   0.045 1261.46   0.030 1261.89   0.030 1400.00
X1     5      34    3.00   44.00    49.0    49.0    49.0
GR1263.7    1.001263.641    3.001263.161    3.201262.626    4.101262.573    4.70
GR1262.1    5.001261.746    6.501261.622    8.001261.468    9.301261.371   10.00
GR1261.3   12.001261.181   14.001261.164   16.001261.038   17.601261.020   18.00
GR1261.0   20.001261.165   22.001261.248   24.001261.349   26.001261.368   28.00
GR1261.3   30.001261.314   32.001261.404   33.601261.448   34.601261.614   35.20
GR1261.8   37.001261.448   38.901261.328   40.001261.455   41.501261.863   42.80
GR1262.4   43.701263.026   44.001263.195   45.001263.120   48.55
NV     4   0.045  1250.0   0.045 1261.56   0.030 1261.97   0.030 1400.00
X1     4      40    3.70   41.00    36.0    36.0    36.0
GR1264.0    1.001263.961    3.401263.303    3.701262.545    4.601262.097    5.40
GR1261.6    6.401261.489    7.101261.389    8.001261.341   10.001261.328   10.60
GR1261.4   12.001261.446   13.701261.506   14.501261.507   16.001261.432   18.00
GR1261.4   20.001261.378   22.001261.365   23.001261.283   24.001261.319   25.00
GR1261.3   26.001261.250   27.001261.385   28.001261.402   29.001261.431   30.00
GR1261.5   31.001261.386   32.001261.360   33.001261.479   34.001261.359   35.10
GR1261.4   36.001261.424   37.001261.421   38.001261.538   39.001261.563   39.40
GR1262.5   39.801262.865   40.201263.201   41.001263.193   43.801263.663   43.80
NC 0.065   0.065   0.035     0.6     0.8
NV     4   0.090  1250.0   0.090 1261.74   0.035 1262.06   0.035 1400.00
X1     3      35    5.40   44.80    27.0    27.0    27.0
GR1264.2    1.001264.070    2.301263.506    3.201263.120    5.401262.150    6.10
GR1261.7    7.401261.634    7.901261.660    8.401261.729    9.701261.761   10.90
GR1261.8   12.801261.703   13.501261.605   15.001261.598   17.001261.601   18.00
GR1261.5   21.001261.519   23.001261.421   25.001261.296   26.501261.270   27.00
GR1261.3   29.001261.218   30.001261.230   31.001261.245   33.001261.331   35.00
GR1261.4   37.001261.492   39.001261.437   40.001261.443   41.001261.673   43.00
GR1261.8   43.501262.285   43.901262.663   44.501263.261   44.801263.332   46.55
NV     4   0.060  1250.0   0.060 1261.94   0.035 1262.28   0.035 1400.00
X1     2      31    2.50   50.45    82.0    82.0    82.0
GR1264.3    1.001264.223    2.501262.640    3.501262.221    4.401261.831    6.00
GR1261.6    7.001261.483    9.501261.536   11.101261.551   15.201261.851   16.70
GR1261.8   19.001261.666   22.001261.766   25.001261.829   28.001261.788   32.00
GR1261.7   33.601261.701   36.001261.668   38.001261.766   39.101261.786   40.20
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GR1261.8   41.401261.916   42.601261.898   44.301261.896   45.401261.929   47.20
GR1262.2   48.201262.686   48.701262.826   49.301263.391   49.601263.656   50.45
GR1263.7   55.00
NV     4   0.070  1250.0   0.070 1261.09   0.025 1262.47   0.025 1400.00
X1     1      19    3.90   48.00   125.0   125.0   125.0
GR1264.0    1.001263.891    3.901263.308    5.801262.897    9.501262.378   11.20
GR1262.1   16.701261.912   18.601261.947   20.201261.787   25.001261.732   28.00
GR1261.6   31.001261.699   35.001261.782   39.001262.082   43.001262.445   45.30
GR1262.8   46.301263.510   46.701263.785   48.001263.971   49.90
*       Start of Oxbow Calculations
NC 0.100   0.100   0.040     0.6     0.8
NV     4   0.045  1250.0   0.045 1260.42   0.027 1261.00   0.027 1400.00
X1   -19      57    4.50   57.00   120.0   120.0   120.0
GR1262.6    0.001262.571    2.001262.360    3.001262.358    4.001262.270    4.50
GR1261.2    4.701260.668    5.501260.420    6.101260.337    6.401260.300    7.00
GR1260.2    8.001260.070    9.001260.021   10.001260.051   11.001260.150   12.00
GR1260.2   12.801260.247   13.001260.205   13.501260.140   14.001260.030   15.00
GR1259.9   15.701259.913   16.001259.925   17.001259.945   18.001259.985   19.00
GR1260.0   20.001260.077   21.001260.085   21.201260.143   21.501260.100   21.90
GR1260.1   22.001260.246   23.001260.382   24.001260.421   24.201260.553   25.00
GR1260.7   27.001260.818   29.001260.912   31.001261.016   33.001261.120   35.00
GR1261.2   37.001261.253   39.001261.255   41.001261.266   43.001261.241   45.00
GR1261.3   47.001261.227   49.001261.143   50.701260.880   51.601260.658   52.50
GR1260.5   53.101260.488   53.401260.593   54.001261.031   56.001261.853   57.00
GR1263.6   59.001263.628   60.83
*       Start of Oxbow
QT     8   0.053    0.27    0.50    0.95    3.63    9.96   17.48   25.45
NV     4   0.052 1250.00   0.052 1259.73   0.036 1260.04   0.036 1400.00
X1    13      56    3.50   52.00    41.0    41.0    41.0
GR1262.5    1.001262.394    3.501261.397    4.501260.843    5.501260.831    6.00
GR1260.6    7.001260.560    8.001260.754    9.001260.919   10.001260.981   11.00
GR1261.0   12.001261.064   13.001261.031   14.001261.022   15.001261.030   16.00
GR1260.8   17.001260.767   17.501260.822   18.001260.819   19.001260.807   20.00
GR1260.8   21.001260.745   22.001260.870   23.001260.993   24.001261.022   25.00
GR1261.0   26.001261.042   27.001261.071   28.001261.101   29.001261.131   30.00
GR1261.1   32.001261.101   33.001261.113   34.001261.165   35.001261.181   36.00
GR1261.2   37.001261.230   38.001261.239   39.001261.328   40.001261.390   41.00
GR1261.4   42.001261.468   43.001261.475   44.001261.453   45.001261.450   46.00
GR1261.4   47.001261.453   48.001261.523   49.001260.513   50.001261.349   51.00
GR1261.6   51.701261.971   52.001262.119   52.401262.230   53.001262.475   54.00
GR1262.8   55.24
NV     4   0.057 1250.00   0.057 1260.11   0.057 1260.21   0.057 1400.00
X1    12      30    3.90   43.70   136.0   136.0   136.0
GR1262.6    0.001262.273    3.901261.396    4.701261.140    5.501261.176    6.20
GR1261.3    7.001261.436    7.701261.276    9.001260.953   10.701261.062   12.00
GR1261.1   14.001261.201   16.001261.200   18.001261.275   19.001261.268   20.00
GR1261.1   22.001261.041   24.001261.075   26.001261.172   28.001261.241   30.00
GR1261.1   32.001260.943   33.301261.062   35.001261.072   36.001261.132   38.00
GR1261.0   40.001260.998   42.001261.287   42.801262.411   43.701262.588   44.93
NV     4   0.067 1250.00   0.067 1260.94   0.047 1261.23   0.047 1400.00
X1    11      36    6.00   42.00   105.0   105.0   105.0
GR1263.5    1.001263.033    2.001262.435    4.001261.869    6.001261.452    6.70
GR1261.0    6.901260.930    7.151260.770    7.901260.842    8.601260.946    9.00
GR1261.2   10.001261.184   11.001261.285   12.001261.388   14.001261.471   16.00
GR1261.4   18.001261.326   20.001261.246   22.001261.229   24.001261.157   26.00
GR1261.1   28.001261.006   30.001260.934   31.101260.806   32.001260.764   33.00
GR1260.9   34.001261.397   35.001261.339   36.001261.327   38.001261.234   39.00
GR1261.3   40.001261.618   41.001261.977   42.001262.145   42.301262.640   42.50
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GR1262.8   43.12
*       Very Rough - Debris Fan from Adjacent Hillslope
NV     4   0.125 1250.00   0.125 1260.98   0.045 1261.23   0.045 1400.00
X1  10.2      20    4.00   35.80   102.0   102.0   102.0
GR1263.9    0.001263.266    2.501262.555    4.001261.594    7.001261.226    8.20
GR1261.0    9.001261.230   10.001261.480   11.701261.401   13.501261.244   17.50
GR1261.2   19.701261.016   23.001260.669   26.001260.434   27.701260.603   29.00
GR1260.9   31.501261.214   33.001261.794   34.501262.391   35.801263.807   36.60
NV     4   0.125  1250.0   0.125 1261.02   0.045 1261.22   0.045 1400.00
X1  10.1      25    4.60   37.50    49.0    49.0    49.0
GR1264.5    0.001264.030    2.301262.655    4.601262.285    7.601261.822    9.50
GR1261.6   13.501261.219   16.501261.065   17.701260.783   19.001260.696   20.20
GR1260.6   21.801260.444   23.301260.319   24.501260.213   25.701260.492   27.50
GR1260.7   28.701260.864   30.501260.812   32.501261.219   34.101261.445   34.60
GR1261.9   34.901262.236   37.501262.112   46.001262.572   48.501262.659   50.90
NV     4   0.100  1250.0   0.100 1261.05   0.075 1261.28   0.075 1400.00
X1    10      40    5.40   32.00    89.0    89.0    89.0
GR1262.8    1.001262.821    4.001262.509    4.301262.178    5.401261.298    5.70
GR1261.1    6.101260.811    6.501260.716    7.001260.725    8.001260.747    9.00
GR1260.8   10.001260.874   11.001260.871   12.001260.844   13.001261.069   14.00
GR1261.1   15.001261.207   17.001261.331   19.001261.403   20.701261.444   22.00
GR1261.4   23.001261.404   24.001261.378   25.801261.551   26.801261.683   28.10
GR1261.9   29.001262.085   30.001262.324   31.001262.454   32.001262.454   33.00
GR1262.6   35.001262.554   37.001262.525   39.001262.488   39.801262.652   41.00
GR1262.8   43.001262.869   45.001262.931   47.001263.069   49.001263.228   52.40
NV     4   0.095  1250.0   0.095 1261.08   0.060 1261.29   0.060 1400.00
X1     9      38    3.30   31.00   140.0   140.0   140.0
GR1262.6    2.601261.917    3.301261.333    4.001261.081    4.601260.965    5.50
GR1261.0    6.001261.051    6.501261.013    7.001260.889    8.001260.856    8.70
GR1261.0    9.401261.082   10.001261.105   10.401261.081   10.601261.052   10.85
GR1261.1   11.201261.102   12.201261.095   13.001261.141   14.001261.199   15.00
GR1261.3   17.001261.452   19.001261.489   21.001261.550   23.001261.657   25.00
GR1261.7   27.001261.751   28.001261.810   29.001261.923   30.001262.001   31.00
GR1262.0   33.001262.035   35.001262.047   37.001262.067   39.001262.073   41.00
GR1262.1   42.301262.833   43.501262.955   45.10
NV     4   0.150  1250.0   0.150 1261.18   0.150 1261.45   0.150 1400.00
X1     8      38    5.00   39.70   102.0   102.0   102.0
GR1262.9    1.001262.674    4.501262.316    5.001261.885    6.001261.786    7.00
GR1261.7    8.001261.712    9.001261.654   10.001261.541   11.001261.495   12.00
GR1261.5   13.001261.442   14.001261.338   16.001261.430   17.001261.514   18.00
GR1261.5   19.001261.509   20.001261.466   21.001261.421   22.001261.517   23.00
GR1261.5   24.001261.500   25.001261.421   26.001261.424   27.001261.469   28.00
GR1261.4   29.001261.332   30.001261.184   30.801260.988   32.001260.953   33.00
GR1261.0   34.001261.112   35.001261.177   35.701261.229   37.001261.272   38.00
GR1261.5   39.001262.194   39.701262.665   41.60
*       Upstream End of Oxbow
NV     4   0.060  1250.0   0.060 1261.17   0.060 1261.46   0.060 1400.00
X1     7      37    5.00   32.00    51.0    51.0    51.0
GR1263.4    1.001263.280    2.801262.757    3.401262.170    5.001262.115    6.00
GR1262.1    7.001261.971    8.001261.888    9.001261.789   10.001261.796   11.00
GR1261.8   12.001261.821   13.001261.818   14.001261.817   15.001261.860   16.00
GR1261.8   17.001261.737   18.001261.641   19.001261.666   20.001261.403   21.00
GR1261.3   21.301261.171   22.101261.007   23.001261.027   24.001261.086   25.00
GR1261.0   26.001261.156   27.001261.174   27.401261.449   28.001261.531   29.00
GR1261.8   30.001261.985   31.001262.124   32.001262.310   33.001262.512   34.00
GR1262.9   35.001263.284   36.20
*       Upstream Junction of Oxbow and Cutoff
*       Elevation Should Match Section 6
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NV     4   0.095 1250.00   0.095 1261.31   0.105 1261.80   0.105 1400.00
QT     8   2.832    7.08   14.16   28.32   56.64   84.96  113.28  141.60
X1    96      32    7.40   50.00    93.0    93.0    93.0
GR1263.3    1.001263.373    7.401263.152    7.601262.976    8.001262.325    8.50
GR1261.7   10.601261.701   12.001261.583   14.001261.335   16.101261.217   17.00
GR1261.1   18.001261.005   20.001260.989   22.001260.986   24.001261.015   26.00
GR1261.1   28.001261.059   30.001261.155   32.001261.179   34.001261.164   36.00
GR1261.3   38.001261.303   38.701261.364   39.501261.278   40.201261.137   41.00
GR1261.1   41.601261.287   43.401261.395   43.801261.733   44.001261.935   45.10
GR1262.5   46.001263.046   50.00
EJ
T1
T2      FLOW SPLIT COMPUTATION
T3      DISCHARGE = 7.08 CMS (250 CFS)
J1   -10       3       0       0   0.001       1    .167       0 1261.33       0
J2     2       0      -1       0       0       0
T1
T2      FLOW SPLIT COMPUTATION
T3      DISCHARGE = 14.16 CMS (500 CFS)
J1   -10       4       0       0   0.001       1    .167       0 1261.33       0
J2     3       0      -1       0       0       0
T1
T2      FLOW SPLIT COMPUTATION
T3      DISCHARGE = 28.32 CMS (1000 CFS)
J1   -10       5       0       0   0.001       1    .167       0 1261.33       0
J2     4       0      -1       0       0       0
T1
T2      FLOW SPLIT COMPUTATION
T3      DISCHARGE = 56.64 CMS (2000 CFS)
J1   -10       6       0       0   0.001       1    .167       0 1261.33       0
J2     5       0      -1       0       0       0
T1
T2      FLOW SPLIT COMPUTATION
T3      DISCHARGE = 84.96 CMS (3000 CFS)
J1   -10       7       0       0   0.001       1    .167       0 1261.66       0
J2     6       0      -1       0       0       0
T1
T2      FLOW SPLIT COMPUTATION
T3      DISCHARGE = 113.28 CMS (4000 CFS)
J1   -10       8       0       0   0.001       1    .167       0 1261.94       0
J2     7       0      -1       0       0       0
T1
T2      FLOW SPLIT COMPUTATION
T3      DISCHARGE = 141.60 CMS (5000 CFS)
J1   -10       9       0       0   0.001       1    .167       0 1262.19       0
J2    15       0      -1       0       0       0
ER
```

APPENDIX D.

HEC-2 RESULTS

2.83 cms (100 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1973	0	1	2.83	1262.11	1262.12	0.01	8.13	0.35	125	1261.60	0.0012		0.0012
1973	125	2	2.83	1261.97	1261.97	0.00	9.54	0.30	82	1261.48	0.0018	0.0012	0.0015
1973	207	3	2.83	1261.81	1261.82	0.00	11.72	0.24	27	1261.22	0.0019	0.0018	0.0018
1973	234	4	2.83	1261.76	1261.77	0.01	7.51	0.38	36	1261.39	0.0014	0.0019	0.0016
1973	270	5	2.83	1261.71	1261.72	0.01	8.63	0.33	49	1261.17	0.0010	0.0014	0.0012
1973	319	6	2.83	1261.66	1261.67	0.00	9.15	0.31	93	1261.20	0.0022	0.0010	0.0016
1973	412	7	2.83	1261.36	1261.47	0.11	1.93	1.46	51	1261.00	0.0078	0.0022	0.0050
1973	463	8	2.83	1261.04	1261.07	0.02	4.06	0.70	102	1260.56	0.0021	0.0078	0.0050
1973	565	9	2.83	1260.85	1260.86	0.01	7.66	0.37	140	1259.70	0.0004	0.0021	0.0012
1973	705	10	2.83	1260.79	1260.80	0.01	5.59	0.51	89	1260.34	0.0013	0.0004	0.0009
1973	794	10.1	2.83	1260.64	1260.68	0.04	3.23	0.88	49	1260.18	0.0022	0.0013	0.0018
1973	843	10.2	2.83	1260.57	1260.57	0.00	10.59	0.27	102	1259.71	0.0003	0.0022	0.0013
1973	945	11	2.83	1260.51	1260.54	0.02	4.09	0.69	105	1260.00	0.0022	0.0003	0.0012
1973	1050	12	2.83	1260.29	1260.31	0.01	5.22	0.54	136	1259.90	0.0010	0.0022	0.0016
1973	1186	13	2.83	1260.17	1260.17	0.00	10.37	0.27	41	1259.61	0.0002	0.0010	0.0006
1973	1227	19	2.83	1260.15	1260.16	0.01	8.19	0.35	120	1259.50	0.0011	0.0002	0.0007
1973	1347	20	2.83	1260.03	1260.03	0.01	7.21	0.39	75	1259.29	0.0023	0.0011	0.0017
1973	1422	21	2.83	1259.85	1259.86	0.01	5.55	0.51	75	1259.30	0.0033	0.0023	0.0028
1973	1497	22	2.83	1259.58	1259.61	0.03	4.03	0.70	50	1259.10	0.0030	0.0033	0.0032
1973	1547	23	2.83	1259.45	1259.46	0.01	6.77	0.42	0	1258.82		0.0030	0.0030
1974	0	1	2.83	1262.11	1262.12	0.01	8.11	0.35	125	1261.60	0.0012		0.0012
1974	125	2	2.83	1261.97	1261.97	0.00	9.57	0.30	82	1261.48	0.0020	0.0012	0.0016
1974	207	3	2.83	1261.81	1261.81	0.00	11.57	0.24	27	1261.22	0.0019	0.0020	0.0019
1974	234	4	2.83	1261.75	1261.76	0.01	7.19	0.39	36	1261.39	0.0017	0.0019	0.0018
1974	270	5	2.83	1261.69	1261.70	0.01	8.01	0.35	49	1261.17	0.0016	0.0017	0.0016
1974	319	6	2.83	1261.61	1261.62	0.01	7.66	0.37	47	1261.20	0.0017	0.0016	0.0017
1974	366	14	2.05	1261.53	1261.54	0.01	5.28	0.39	32	1260.80	0.0031	0.0017	0.0024
1974	398	15	2.05	1261.35	1261.44	0.09	1.55	1.32	13	1260.78	0.0415	0.0031	0.0223
1974	411	16	2.05	1260.88	1260.90	0.02	3.14	0.65	15	1260.09	0.0267	0.0415	0.0341
1974	426	17	2.05	1260.44	1260.50	0.06	1.89	1.09	16	1259.45	0.0181	0.0267	0.0224
1974	442	18	2.05	1260.21	1260.21	0.01	5.81	0.35	54	1259.16	0.0009	0.0181	0.0095
1974	496	19	2.83	1260.15	1260.16	0.01	8.19	0.35	120	1259.50	0.0011	0.0009	0.0010
1974	616	20	2.83	1260.03	1260.03	0.01	7.21	0.39	75	1259.29	0.0023	0.0011	0.0017
1974	691	21	2.83	1259.85	1259.86	0.01	5.55	0.51	75	1259.30	0.0033	0.0023	0.0028
1974	766	22	2.83	1259.58	1259.61	0.03	4.03	0.70	50	1259.10	0.0030	0.0033	0.0032
1974	816	23	2.83	1259.45	1259.46	0.01	6.77	0.42	0	1258.82		0.0030	0.0030
1974	319	96	2.83	1261.61	1261.61	0.01	7.46	0.38	93	1261.20	0.0037	0.0016	0.0026
1974	412	7	0.78	1261.23	1261.27	0.04	0.89	0.87	51	1261.00	0.0065	0.0037	0.0051
1974	463	8	0.78	1260.92	1260.94	0.02	1.34	0.58	102	1260.56	0.0030	0.0065	0.0048
1974	565	9	0.78	1260.62	1260.63	0.00	4.00	0.20	140	1259.70	0.0002	0.0030	0.0016
1974	705	10	0.78	1260.59	1260.60	0.01	2.43	0.32	89	1260.34	0.0013	0.0002	0.0008
1974	794	10.1	0.78	1260.46	1260.48	0.02	1.23	0.63	49	1260.18	0.0024	0.0013	0.0019
1974	843	10.2	0.78	1260.36	1260.36	0.00	6.96	0.11	102	1259.71	0.0001	0.0024	0.0013

2.83 cms (100 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1974	945	11	0.78	1260.34	1260.35	0.01	1.47	0.53	105	1260.00	0.0013	0.0001	0.0007
1974	1050	12	0.78	1260.20	1260.21	0.00	2.99	0.26	136	1259.90	0.0004	0.0013	0.0009
1974	1186	13	0.78	1260.16	1260.16	0.00	10.00	0.08	41	1259.61	0.0000	0.0004	0.0002
1974	1227	-19	2.83	1260.15	1260.16	0.01	8.25	0.34	120	1259.50	0.0011	0.0000	0.0005
1990	0	1	2.83	1262.11	1262.11	0.01	8.04	0.35	125	1261.60	0.0012		0.0012
1990	125	2	2.83	1261.96	1261.96	0.00	9.68	0.29	82	1261.48	0.0029	0.0012	0.0021
1990	207	3	2.83	1261.72	1261.72	0.01	8.47	0.33	27	1261.22	0.0041	0.0029	0.0035
1990	234	4	2.83	1261.60	1261.61	0.01	6.52	0.43	36	1261.25	0.0028	0.0041	0.0034
1990	270	5	2.83	1261.50	1261.51	0.01	6.77	0.42	49	1261.00	0.0029	0.0028	0.0028
1990	319	6	2.83	1261.36	1261.37	0.01	6.68	0.42	47	1260.99	0.0034	0.0029	0.0031
1990	366	14	2.78	1261.21	1261.21	0.01	8.20	0.34	32	1260.53	0.0059	0.0034	0.0047
1990	398	15	2.78	1260.99	1261.02	0.03	3.78	0.73	13	1260.42	0.0277	0.0059	0.0168
1990	411	16	2.78	1260.65	1260.66	0.01	7.88	0.35	15	1259.49	0.0073	0.0277	0.0175
1990	426	17	2.78	1260.54	1260.55	0.01	5.86	0.47	16	1258.89	0.0025	0.0073	0.0049
1990	442	18	2.78	1260.51	1260.51	0.00	29.17	0.10	54	1258.31	0.0002	0.0025	0.0013
1990	496	19	2.83	1260.49	1260.50	0.01	7.14	0.40	120	1259.90	0.0007	0.0002	0.0004
1990	616	20	2.83	1260.42	1260.42	0.00	15.48	0.18	75	1259.29	0.0004	0.0007	0.0005
1990	691	21	2.83	1260.38	1260.39	0.01	6.83	0.41	75	1259.80	0.0019	0.0004	0.0011
1990	766	22	2.83	1260.23	1260.25	0.02	5.18	0.55	50	1259.70	0.0022	0.0019	0.0020
1990	816	23	2.83	1260.13	1260.14	0.01	6.82	0.42	0	1259.51		0.0022	0.0022
1990	319	96	2.83	1261.36	1261.37	0.01	6.40	0.44	93	1260.99	0.0015	0.0029	0.0022
1990	412	7	0.05	1261.23	1261.23	0.00	0.87	0.06	51	1261.00	0.0004	0.0015	0.0009
1990	463	8	0.05	1261.21	1261.21	0.00	0.85	0.06	102	1260.95	0.0008	0.0004	0.0006
1990	565	9	0.05	1261.13	1261.13	0.00	0.93	0.06	140	1260.86	0.0003	0.0008	0.0005
1990	705	10	0.05	1261.09	1261.09	0.00	2.06	0.03	89	1260.72	0.0001	0.0003	0.0002
1990	794	10.1	0.05	1261.08	1261.08	0.00	7.08	0.01	49	1260.21	0.0000	0.0001	0.0001
1990	843	10.2	0.05	1261.08	1261.08	0.00	3.24	0.02	102	1260.43	0.0000	0.0000	0.0000
1990	945	11	0.05	1261.08	1261.08	0.00	1.42	0.04	105	1260.76	0.0001	0.0000	0.0000
1990	1050	12	0.05	1261.07	1261.07	0.00	0.56	0.09	136	1260.94	0.0029	0.0001	0.0015
1990	1186	13	0.05	1260.67	1260.67	0.01	0.14	0.38	41	1260.51	0.0041	0.0029	0.0035
1990	1227	-19	2.83	1260.49	1260.50	0.01	7.10	0.40	120	1259.90	0.0007	0.0041	0.0024

7.08 cms (250 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1973	0	1	7.08	1262.26	1262.28	0.02	12.54	0.56	125	1261.60	0.0014		0.0014
1973	125	2	7.08	1262.10	1262.11	0.01	15.44	0.46	82	1261.48	0.0015	0.0014	0.0014
1973	207	3	7.08	1261.98	1261.99	0.01	17.85	0.40	27	1261.22	0.0011	0.0015	0.0013
1973	234	4	7.08	1261.94	1261.96	0.01	13.34	0.53	36	1261.39	0.0011	0.0011	0.0011
1973	270	5	7.08	1261.91	1261.92	0.01	15.07	0.47	49	1261.17	0.0010	0.0011	0.0011
1973	319	6	7.08	1261.86	1261.87	0.01	15.04	0.47	93	1261.20	0.0019	0.0010	0.0015
1973	412	7	7.08	1261.56	1261.69	0.14	4.32	1.64	51	1261.00	0.0086	0.0019	0.0053
1973	463	8	7.08	1261.22	1261.25	0.03	8.91	0.80	102	1260.56	0.0013	0.0086	0.0050
1973	565	9	7.08	1261.11	1261.12	0.02	12.51	0.57	140	1259.70	0.0005	0.0013	0.0009
1973	705	10	7.08	1261.02	1261.05	0.03	10.02	0.71	89	1260.34	0.0017	0.0005	0.0011
1973	794	10.1	7.08	1260.83	1260.90	0.07	5.87	1.21	49	1260.18	0.0029	0.0017	0.0023
1973	843	10.2	7.08	1260.75	1260.76	0.01	14.35	0.49	102	1259.71	0.0006	0.0029	0.0017
1973	945	11	7.08	1260.66	1260.70	0.04	8.33	0.85	105	1260.00	0.0018	0.0006	0.0012
1973	1050	12	7.08	1260.49	1260.51	0.02	11.15	0.63	136	1259.90	0.0007	0.0018	0.0013
1973	1186	13	7.08	1260.41	1260.41	0.01	20.70	0.34	41	1259.61	0.0002	0.0007	0.0005
1973	1227	19	7.08	1260.38	1260.40	0.01	13.53	0.52	120	1259.50	0.0013	0.0002	0.0007
1973	1347	20	7.08	1260.23	1260.25	0.02	11.43	0.62	75	1259.29	0.0031	0.0013	0.0022
1973	1422	21	7.08	1259.99	1260.02	0.03	9.73	0.73	75	1259.30	0.0029	0.0031	0.0030
1973	1497	22	7.08	1259.78	1259.80	0.03	9.87	0.72	50	1259.10	0.0020	0.0029	0.0025
1973	1547	23	7.08	1259.68	1259.70	0.02	12.47	0.57	0	1258.82		0.0020	0.0020
1974	0	1	7.08	1262.26	1262.28	0.02	12.57	0.56	125	1261.60	0.0014		0.0014
1974	125	2	7.08	1262.10	1262.11	0.01	15.30	0.46	82	1261.48	0.0017	0.0014	0.0015
1974	207	3	7.08	1261.96	1261.97	0.01	17.26	0.41	27	1261.22	0.0015	0.0017	0.0016
1974	234	4	7.08	1261.92	1261.93	0.02	12.44	0.57	36	1261.39	0.0014	0.0015	0.0014
1974	270	5	7.08	1261.87	1261.88	0.01	13.56	0.52	49	1261.17	0.0014	0.0014	0.0014
1974	319	6	7.08	1261.79	1261.81	0.02	13.02	0.54	47	1261.20	0.0017	0.0014	0.0016
1974	366	14	4.38	1261.72	1261.73	0.02	7.34	0.60	32	1260.80	0.0034	0.0017	0.0026
1974	398	15	4.38	1261.49	1261.62	0.13	2.77	1.58	13	1260.78	0.0285	0.0034	0.0159
1974	411	16	4.38	1261.22	1261.25	0.03	5.59	0.78	15	1260.09	0.0320	0.0285	0.0302
1974	426	17	4.38	1260.61	1260.77	0.15	2.51	1.75	16	1259.45	0.0181	0.0320	0.0251
1974	442	18	4.38	1260.46	1260.48	0.02	8.05	0.54	54	1259.16	0.0015	0.0181	0.0098
1974	496	19	7.08	1260.38	1260.40	0.01	13.53	0.52	120	1259.50	0.0013	0.0015	0.0014
1974	616	20	7.08	1260.23	1260.25	0.02	11.43	0.62	75	1259.29	0.0031	0.0013	0.0022
1974	691	21	7.08	1259.99	1260.02	0.03	9.73	0.73	75	1259.30	0.0029	0.0031	0.0030
1974	766	22	7.08	1259.78	1259.80	0.03	9.87	0.72	50	1259.10	0.0020	0.0029	0.0025
1974	816	23	7.08	1259.68	1259.70	0.02	12.47	0.57	0	1258.82		0.0020	0.0020
1974	319	96	7.08	1261.79	1261.81	0.02	12.89	0.55	93	1261.20	0.0037	0.0014	0.0025
1974	412	7	2.7	1261.36	1261.47	0.11	1.86	1.45	51	1261.00	0.0080	0.0037	0.0058
1974	463	8	2.7	1261.04	1261.06	0.02	3.91	0.69	102	1260.56	0.0022	0.0080	0.0051
1974	565	9	2.7	1260.84	1260.84	0.01	7.47	0.36	140	1259.70	0.0004	0.0022	0.0013
1974	705	10	2.7	1260.78	1260.79	0.01	5.43	0.50	89	1260.34	0.0013	0.0004	0.0009
1974	794	10.1	2.7	1260.63	1260.67	0.04	3.15	0.86	49	1260.18	0.0022	0.0013	0.0018
1974	843	10.2	2.7	1260.56	1260.56	0.00	10.48	0.26	102	1259.71	0.0003	0.0022	0.0013

7.08 cms (250 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1974	945	11	2.7	1260.51	1260.53	0.02	4.29	0.63	105	1260.00	0.0010	0.0003	0.0006
1974	1050	12	2.7	1260.43	1260.43	0.00	8.95	0.30	136	1259.90	0.0001	0.0010	0.0005
1974	1186	13	2.7	1260.41	1260.41	0.00	20.58	0.13	41	1259.61	0.0002	0.0001	0.0002
1974	1227	-19	7.08	1260.38	1260.40	0.01	13.56	0.52	120	1259.50	0.0013	0.0002	0.0007
1990	0	1	7.08	1262.26	1262.28	0.02	12.62	0.56	125	1261.60	0.0014		0.0014
1990	125	2	7.08	1262.10	1262.11	0.01	15.39	0.46	82	1261.48	0.0029	0.0014	0.0021
1990	207	3	7.08	1261.86	1261.87	0.01	13.38	0.53	27	1261.22	0.0037	0.0029	0.0033
1990	234	4	7.08	1261.75	1261.77	0.02	11.09	0.64	36	1261.25	0.0025	0.0037	0.0031
1990	270	5	7.08	1261.67	1261.68	0.02	11.78	0.60	49	1261.00	0.0020	0.0025	0.0023
1990	319	6	7.08	1261.57	1261.58	0.02	12.39	0.57	47	1260.99	0.0028	0.0020	0.0024
1990	366	14	6.81	1261.44	1261.45	0.01	13.34	0.51	32	1260.53	0.0078	0.0028	0.0053
1990	398	15	6.81	1261.16	1261.20	0.04	7.42	0.92	13	1260.42	0.0223	0.0078	0.0151
1990	411	16	6.81	1260.90	1260.91	0.01	12.91	0.53	15	1259.49	0.0067	0.0223	0.0145
1990	426	17	6.81	1260.77	1260.81	0.03	8.49	0.80	16	1258.89	0.0044	0.0067	0.0055
1990	442	18	6.81	1260.74	1260.74	0.00	35.25	0.19	54	1258.31	0.0004	0.0044	0.0024
1990	496	19	7.08	1260.70	1260.72	0.02	11.65	0.61	120	1259.90	0.0008	0.0004	0.0006
1990	616	20	7.08	1260.62	1260.62	0.01	20.26	0.35	75	1259.29	0.0007	0.0008	0.0008
1990	691	21	7.08	1260.56	1260.57	0.02	12.35	0.57	75	1259.80	0.0016	0.0007	0.0011
1990	766	22	7.08	1260.43	1260.45	0.02	11.75	0.60	50	1259.70	0.0014	0.0016	0.0015
1990	816	23	7.08	1260.37	1260.38	0.02	12.46	0.57	0	1259.51		0.0014	0.0014
1990	319	96	7.08	1261.57	1261.59	0.02	12.56	0.56	93	1260.99	0.0019	0.0020	0.0020
1990	412	7	0.27	1261.41	1261.41	0.00	2.11	0.13	51	1261.00	0.0006	0.0019	0.0013
1990	463	8	0.27	1261.38	1261.38	0.00	2.13	0.13	102	1260.95	0.0012	0.0006	0.0009
1990	565	9	0.27	1261.26	1261.26	0.00	2.37	0.11	140	1260.86	0.0004	0.0012	0.0008
1990	705	10	0.27	1261.21	1261.21	0.00	3.19	0.08	89	1260.72	0.0001	0.0004	0.0002
1990	794	10.1	0.27	1261.20	1261.20	0.00	8.96	0.03	49	1260.21	0.0000	0.0001	0.0001
1990	843	10.2	0.27	1261.20	1261.20	0.00	4.80	0.06	102	1260.43	0.0001	0.0000	0.0000
1990	945	11	0.27	1261.19	1261.19	0.00	2.56	0.11	105	1260.76	0.0004	0.0001	0.0002
1990	1050	12	0.27	1261.14	1261.15	0.00	1.99	0.14	136	1260.94	0.0023	0.0004	0.0013
1990	1186	13	0.27	1260.83	1260.84	0.01	0.83	0.33	41	1260.51	0.0029	0.0023	0.0026
1990	1227	-19	7.08	1260.70	1260.72	0.02	11.64	0.61	120	1259.90	0.0008	0.0029	0.0019

14.16 cms (500 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1973	0	1	14.16	1262.41	1262.44	0.03	17.10	0.83	125	1261.60	0.0014		0.0014
1973	125	2	14.16	1262.25	1262.27	0.02	22.16	0.64	82	1261.48	0.0011	0.0014	0.0012
1973	207	3	14.16	1262.17	1262.18	0.02	24.88	0.57	27	1261.22	0.0007	0.0011	0.0009
1973	234	4	14.16	1262.14	1262.16	0.03	20.03	0.71	36	1261.39	0.0008	0.0007	0.0008
1973	270	5	14.16	1262.11	1262.13	0.02	22.59	0.63	49	1261.17	0.0008	0.0008	0.0008
1973	319	6	14.16	1262.07	1262.09	0.02	22.25	0.64	93	1261.20	0.0019	0.0008	0.0014
1973	412	7	14.16	1261.72	1261.91	0.19	7.34	1.93	51	1261.00	0.0080	0.0019	0.0050
1973	463	8	14.16	1261.46	1261.50	0.04	16.50	0.86	102	1260.56	0.0009	0.0080	0.0045
1973	565	9	14.16	1261.38	1261.41	0.03	18.38	0.77	140	1259.70	0.0006	0.0009	0.0008
1973	705	10	14.16	1261.28	1261.32	0.04	15.39	0.92	89	1260.34	0.0019	0.0006	0.0013
1973	794	10.1	14.16	1261.03	1261.15	0.12	9.22	1.54	49	1260.18	0.0033	0.0019	0.0026
1973	843	10.2	14.16	1260.96	1260.99	0.03	19.03	0.74	102	1259.71	0.0009	0.0033	0.0021
1973	945	11	14.16	1260.84	1260.90	0.05	13.87	1.02	105	1260.00	0.0015	0.0009	0.0012
1973	1050	12	14.16	1260.71	1260.74	0.03	18.32	0.77	136	1259.90	0.0007	0.0015	0.0011
1973	1186	13	14.16	1260.64	1260.65	0.01	31.06	0.46	41	1259.61	0.0005	0.0007	0.0006
1973	1227	19	14.16	1260.60	1260.63	0.03	19.92	0.71	120	1259.50	0.0013	0.0005	0.0009
1973	1347	20	14.16	1260.43	1260.47	0.04	15.76	0.90	75	1259.29	0.0036	0.0013	0.0025
1973	1422	21	14.16	1260.17	1260.20	0.04	16.33	0.87	75	1259.30	0.0021	0.0036	0.0029
1973	1497	22	14.16	1260.01	1260.04	0.03	17.26	0.82	50	1259.10	0.0014	0.0021	0.0018
1973	1547	23	14.16	1259.94	1259.97	0.02	20.63	0.69	0	1258.82		0.0014	0.0014
1974	0	1	14.16	1262.41	1262.44	0.04	16.87	0.84	125	1261.60	0.0015		0.0015
1974	125	2	14.16	1262.23	1262.25	0.02	21.23	0.67	82	1261.48	0.0013	0.0015	0.0014
1974	207	3	14.16	1262.12	1262.14	0.02	23.20	0.61	27	1261.22	0.0011	0.0013	0.0012
1974	234	4	14.16	1262.08	1262.11	0.03	18.08	0.78	36	1261.39	0.0011	0.0011	0.0011
1974	270	5	14.16	1262.04	1262.07	0.03	19.93	0.71	49	1261.17	0.0014	0.0011	0.0013
1974	319	6	14.16	1261.97	1262.00	0.03	18.59	0.76	47	1261.20	0.0015	0.0014	0.0015
1974	366	14	7.03	1261.90	1261.93	0.03	9.28	0.76	32	1260.80	0.0044	0.0015	0.0029
1974	398	15	7.03	1261.63	1261.79	0.16	4.46	1.76	13	1260.78	0.0238	0.0044	0.0141
1974	411	16	7.03	1261.44	1261.48	0.05	7.26	0.97	15	1260.09	0.0247	0.0238	0.0243
1974	426	17	7.03	1260.94	1261.11	0.17	3.86	1.82	16	1259.45	0.0244	0.0247	0.0245
1974	442	18	7.03	1260.70	1260.72	0.02	10.30	0.68	54	1259.16	0.0017	0.0244	0.0130
1974	496	19	14.16	1260.60	1260.63	0.03	19.92	0.71	120	1259.50	0.0013	0.0017	0.0015
1974	616	20	14.16	1260.43	1260.47	0.04	15.76	0.90	75	1259.29	0.0036	0.0013	0.0025
1974	691	21	14.16	1260.17	1260.20	0.04	16.33	0.87	75	1259.30	0.0021	0.0036	0.0029
1974	766	22	14.16	1260.01	1260.04	0.03	17.26	0.82	50	1259.10	0.0014	0.0021	0.0018
1974	816	23	14.16	1259.94	1259.97	0.02	20.63	0.69	0	1258.82		0.0014	0.0014
1974	319	96	14.16	1261.97	1262.00	0.03	18.87	0.75	93	1261.20	0.0032	0.0014	0.0023
1974	412	7	7.13	1261.56	1261.70	0.14	4.37	1.63	51	1261.00	0.0086	0.0032	0.0059
1974	463	8	7.13	1261.23	1261.26	0.03	9.04	0.79	102	1260.56	0.0013	0.0086	0.0050
1974	565	9	7.13	1261.11	1261.13	0.02	12.65	0.56	140	1259.70	0.0006	0.0013	0.0009
1974	705	10	7.13	1261.03	1261.05	0.03	9.93	0.72	89	1260.34	0.0015	0.0006	0.0010
1974	794	10.1	7.13	1260.86	1260.92	0.06	6.43	1.11	49	1260.18	0.0022	0.0015	0.0019
1974	843	10.2	7.13	1260.80	1260.81	0.01	15.38	0.46	102	1259.71	0.0005	0.0022	0.0014

14.16 cms (500 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1974	945	11	7.13	1260.74	1260.76	0.02	10.62	0.67	105	1260.00	0.0009	0.0005	0.0007
1974	1050	12	7.13	1260.66	1260.67	0.01	16.57	0.43	136	1259.90	0.0002	0.0009	0.0005
1974	1186	13	7.13	1260.64	1260.64	0.00	31.20	0.23	41	1259.61	0.0002	0.0002	0.0002
1974	1227	-19	14.16	1260.60	1260.63	0.03	19.93	0.71	120	1259.50	0.0013	0.0002	0.0008
1990	0	1	14.16	1262.41	1262.44	0.03	17.22	0.82	125	1261.60	0.0016		0.0016
1990	125	2	14.16	1262.22	1262.24	0.02	20.59	0.69	82	1261.48	0.0027	0.0016	0.0021
1990	207	3	14.16	1261.99	1262.02	0.03	18.04	0.78	27	1261.22	0.0030	0.0027	0.0028
1990	234	4	14.16	1261.90	1261.94	0.04	16.17	0.88	36	1261.25	0.0019	0.0030	0.0025
1990	270	5	14.16	1261.83	1261.87	0.03	17.72	0.80	49	1261.00	0.0018	0.0019	0.0019
1990	319	6	14.16	1261.75	1261.78	0.03	18.19	0.78	47	1260.99	0.0026	0.0018	0.0022
1990	366	14	13.66	1261.63	1261.66	0.03	18.18	0.75	32	1260.53	0.0078	0.0026	0.0052
1990	398	15	13.66	1261.34	1261.41	0.08	11.06	1.24	13	1260.42	0.0192	0.0078	0.0135
1990	411	16	13.66	1261.13	1261.16	0.03	17.83	0.77	15	1259.49	0.0073	0.0192	0.0133
1990	426	17	13.66	1260.97	1261.05	0.08	11.11	1.23	16	1258.89	0.0056	0.0073	0.0065
1990	442	18	13.66	1260.95	1260.96	0.01	40.94	0.33	54	1258.31	0.0004	0.0056	0.0030
1990	496	19	14.16	1260.90	1260.94	0.04	16.87	0.84	120	1259.90	0.0009	0.0004	0.0006
1990	616	20	14.16	1260.81	1260.83	0.02	25.26	0.56	75	1259.29	0.0007	0.0009	0.0008
1990	691	21	14.16	1260.76	1260.78	0.02	20.71	0.68	75	1259.80	0.0011	0.0007	0.0009
1990	766	22	14.16	1260.67	1260.70	0.02	20.33	0.70	50	1259.70	0.0010	0.0011	0.0010
1990	816	23	14.16	1260.62	1260.65	0.02	20.61	0.69	0	1259.51		0.0010	0.0010
1990	319	96	14.16	1261.75	1261.78	0.03	18.13	0.78	93	1260.99	0.0027	0.0018	0.0023
1990	412	7	0.5	1261.53	1261.53	0.00	3.01	0.17	51	1261.00	0.0008	0.0027	0.0017
1990	463	8	0.5	1261.49	1261.49	0.00	3.69	0.14	102	1260.95	0.0015	0.0008	0.0011
1990	565	9	0.5	1261.34	1261.34	0.00	3.36	0.15	140	1260.86	0.0004	0.0015	0.0009
1990	705	10	0.5	1261.28	1261.28	0.00	4.15	0.12	89	1260.72	0.0002	0.0004	0.0003
1990	794	10.1	0.5	1261.26	1261.26	0.00	10.12	0.05	49	1260.21	0.0000	0.0002	0.0001
1990	843	10.2	0.5	1261.26	1261.26	0.00	5.85	0.09	102	1260.43	0.0001	0.0000	0.0000
1990	945	11	0.5	1261.25	1261.25	0.00	3.60	0.14	105	1260.76	0.0007	0.0001	0.0004
1990	1050	12	0.5	1261.18	1261.18	0.00	2.60	0.19	136	1260.94	0.0015	0.0007	0.0011
1990	1186	13	0.5	1260.98	1260.98	0.00	2.77	0.18	41	1260.51	0.0010	0.0015	0.0012
1990	1227	-19	14.16	1260.90	1260.94	0.04	16.85	0.84	120	1259.90	0.0009	0.0010	0.0009

28.32 cms (1000 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1973	0	1	28.32	1262.68	1262.73	0.06	26.59	1.07	125	1261.60	0.0011		0.0011
1973	125	2	28.32	1262.56	1262.59	0.03	35.68	0.79	82	1261.48	0.0009	0.0011	0.0010
1973	207	3	28.32	1262.49	1262.52	0.03	37.03	0.76	27	1261.22	0.0011	0.0009	0.0010
1973	234	4	28.32	1262.45	1262.49	0.04	30.88	0.92	36	1261.39	0.0008	0.0011	0.0010
1973	270	5	28.32	1262.43	1262.46	0.03	34.78	0.81	49	1261.17	0.0008	0.0008	0.0008
1973	319	6	28.32	1262.39	1262.42	0.04	34.04	0.83	93	1261.20	0.0020	0.0008	0.0014
1973	412	7	28.32	1261.98	1262.23	0.25	12.78	2.22	51	1261.00	0.0065	0.0020	0.0043
1973	463	8	28.32	1261.86	1261.90	0.05	29.28	0.98	102	1260.56	0.0006	0.0065	0.0035
1973	565	9	28.32	1261.78	1261.84	0.05	27.72	1.02	140	1259.70	0.0008	0.0006	0.0007
1973	705	10	28.32	1261.65	1261.73	0.07	23.87	1.19	89	1260.34	0.0022	0.0008	0.0015
1973	794	10.1	28.32	1261.33	1261.53	0.19	14.50	1.95	49	1260.18	0.0043	0.0022	0.0033
1973	843	10.2	28.32	1261.26	1261.32	0.06	26.22	1.08	102	1259.71	0.0011	0.0043	0.0027
1973	945	11	28.32	1261.13	1261.21	0.08	23.23	1.22	105	1260.00	0.0013	0.0011	0.0012
1973	1050	12	28.32	1261.02	1261.07	0.05	29.32	0.97	136	1259.90	0.0007	0.0013	0.0010
1973	1186	13	28.32	1260.96	1260.98	0.02	45.68	0.62	41	1259.61	0.0007	0.0007	0.0007
1973	1227	19	28.32	1260.91	1260.95	0.04	31.97	0.89	120	1259.50	0.0019	0.0007	0.0013
1973	1347	20	28.32	1260.63	1260.72	0.10	20.55	1.38	75	1259.29	0.0035	0.0019	0.0027
1973	1422	21	28.32	1260.40	1260.46	0.06	25.95	1.09	75	1259.30	0.0017	0.0035	0.0026
1973	1497	22	28.32	1260.28	1260.33	0.06	26.76	1.06	50	1259.10	0.0012	0.0017	0.0015
1973	1547	23	28.32	1260.23	1260.27	0.04	31.50	0.90	0	1258.82		0.0012	0.0012
1974	0	1	28.32	1262.64	1262.70	0.06	25.28	1.12	125	1261.60	0.0014		0.0014
1974	125	2	28.32	1262.49	1262.53	0.04	32.69	0.87	82	1261.48	0.0012	0.0014	0.0013
1974	207	3	28.32	1262.39	1262.43	0.04	33.40	0.85	27	1261.22	0.0011	0.0012	0.0012
1974	234	4	28.32	1262.34	1262.40	0.06	26.98	1.05	36	1261.39	0.0014	0.0011	0.0013
1974	270	5	28.32	1262.30	1262.35	0.05	29.75	0.95	49	1261.17	0.0014	0.0014	0.0014
1974	319	6	28.32	1262.22	1262.28	0.05	27.67	1.02	47	1261.20	0.0023	0.0014	0.0019
1974	366	14	13.65	1262.10	1262.17	0.07	12.98	1.16	32	1260.80	0.0053	0.0023	0.0038
1974	398	15	13.65	1261.88	1262.00	0.12	9.85	1.67	13	1260.78	0.0108	0.0053	0.0080
1974	411	16	13.65	1261.76	1261.86	0.10	9.71	1.41	15	1260.09	0.0187	0.0108	0.0147
1974	426	17	13.65	1261.27	1261.58	0.31	5.50	2.48	16	1259.45	0.0300	0.0187	0.0243
1974	442	18	13.65	1261.05	1261.10	0.05	14.97	0.95	54	1259.16	0.0028	0.0300	0.0164
1974	496	19	28.32	1260.91	1260.95	0.04	31.97	0.89	120	1259.50	0.0019	0.0028	0.0023
1974	616	20	28.32	1260.63	1260.72	0.10	20.55	1.38	75	1259.29	0.0035	0.0019	0.0027
1974	691	21	28.32	1260.40	1260.46	0.06	25.95	1.09	75	1259.30	0.0017	0.0035	0.0026
1974	766	22	28.32	1260.28	1260.33	0.06	26.76	1.06	50	1259.10	0.0012	0.0017	0.0015
1974	816	23	28.32	1260.23	1260.27	0.04	31.50	0.90	0	1258.82		0.0012	0.0012
1974	319	96	28.32	1262.22	1262.28	0.05	27.55	1.03	93	1261.20	0.0038	0.0014	0.0026
1974	412	7	14.67	1261.73	1261.93	0.20	7.45	1.97	51	1261.00	0.0078	0.0038	0.0058
1974	463	8	14.67	1261.49	1261.53	0.04	17.30	0.85	102	1260.56	0.0008	0.0078	0.0043
1974	565	9	14.67	1261.42	1261.45	0.03	19.09	0.77	140	1259.70	0.0006	0.0008	0.0007
1974	705	10	14.67	1261.32	1261.36	0.04	16.30	0.90	89	1260.34	0.0015	0.0006	0.0011
1974	794	10.1	14.67	1261.13	1261.23	0.09	10.85	1.35	49	1260.18	0.0024	0.0015	0.0020
1974	843	10.2	14.67	1261.09	1261.11	0.02	22.01	0.67	102	1259.71	0.0005	0.0024	0.0015

28.32 cms (1000 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1974	945	11	14.67	1261.03	1261.06	0.03	20.07	0.73	105	1260.00	0.0006	0.0005	0.0005
1974	1050	12	14.67	1260.99	1261.00	0.01	28.20	0.52	136	1259.90	0.0001	0.0006	0.0004
1974	1186	13	14.67	1260.97	1260.98	0.01	46.19	0.32	41	1259.61	0.0007	0.0001	0.0004
1974	1227	-19	28.32	1260.91	1260.95	0.04	32.02	0.88	120	1259.50	0.0019	0.0007	0.0013
1990	0	1	28.32	1262.61	1262.68	0.07	24.25	1.17	125	1261.60	0.0018		0.0018
1990	125	2	28.32	1262.40	1262.45	0.05	28.80	0.98	82	1261.48	0.0022	0.0018	0.0020
1990	207	3	28.32	1262.21	1262.27	0.06	26.44	1.07	27	1261.22	0.0026	0.0022	0.0024
1990	234	4	28.32	1262.13	1262.20	0.07	24.37	1.16	36	1261.25	0.0017	0.0026	0.0021
1990	270	5	28.32	1262.08	1262.14	0.06	26.88	1.05	49	1261.00	0.0018	0.0017	0.0018
1990	319	6	28.32	1261.99	1262.05	0.06	26.48	1.07	47	1260.99	0.0026	0.0018	0.0022
1990	366	14	27.37	1261.87	1261.93	0.06	24.24	1.13	32	1260.53	0.0069	0.0026	0.0047
1990	398	15	27.37	1261.56	1261.71	0.15	15.71	1.74	13	1260.42	0.0162	0.0069	0.0115
1990	411	16	27.37	1261.44	1261.50	0.06	24.68	1.11	15	1259.49	0.0060	0.0162	0.0111
1990	426	17	27.37	1261.23	1261.41	0.18	14.56	1.88	16	1258.89	0.0081	0.0060	0.0071
1990	442	18	27.37	1261.26	1261.28	0.02	50.19	0.55	54	1258.31	0.0007	0.0081	0.0044
1990	496	19	28.32	1261.18	1261.24	0.06	25.93	1.09	120	1259.90	0.0010	0.0007	0.0009
1990	616	20	28.32	1261.08	1261.12	0.04	32.60	0.87	75	1259.29	0.0005	0.0010	0.0008
1990	691	21	28.32	1261.04	1261.08	0.04	32.44	0.87	75	1259.80	0.0011	0.0005	0.0008
1990	766	22	28.32	1260.96	1261.00	0.04	30.36	0.93	50	1259.70	0.0010	0.0011	0.0010
1990	816	23	28.32	1260.91	1260.95	0.04	31.68	0.89	0	1259.51		0.0010	0.0010
1990	319	96	28.32	1261.99	1262.05	0.06	26.14	1.08	93	1260.99	0.0041	0.0018	0.0030
1990	412	7	0.95	1261.66	1261.67	0.00	4.08	0.23	51	1261.00	0.0012	0.0041	0.0026
1990	463	8	0.95	1261.61	1261.61	0.00	6.98	0.14	102	1260.95	0.0012	0.0012	0.0012
1990	565	9	0.95	1261.49	1261.49	0.00	5.58	0.17	140	1260.86	0.0006	0.0012	0.0009
1990	705	10	0.95	1261.41	1261.41	0.00	5.97	0.16	89	1260.72	0.0003	0.0006	0.0005
1990	794	10.1	0.95	1261.38	1261.38	0.00	12.32	0.08	49	1260.21	0.0000	0.0003	0.0002
1990	843	10.2	0.95	1261.38	1261.38	0.00	8.32	0.11	102	1260.43	0.0002	0.0000	0.0001
1990	945	11	0.95	1261.36	1261.36	0.00	6.07	0.16	105	1260.76	0.0004	0.0002	0.0003
1990	1050	12	0.95	1261.32	1261.32	0.00	7.24	0.13	136	1260.94	0.0003	0.0004	0.0003
1990	1186	13	0.95	1261.28	1261.28	0.00	11.01	0.09	41	1260.51	0.0010	0.0003	0.0006
1990	1227	-19	28.32	1261.18	1261.24	0.06	26.29	1.08	120	1259.90	0.0010	0.0010	0.0010

56.64 cms (2000 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1973	0	1	56.64	1263.12	1263.21	0.09	42.89	1.32	125	1261.60	0.0011		0.0011
1973	125	2	56.64	1263.02	1263.07	0.05	56.97	0.99	82	1261.48	0.0009	0.0011	0.0010
1973	207	3	56.64	1262.95	1263.00	0.05	54.92	1.03	27	1261.22	0.0011	0.0009	0.0010
1973	234	4	56.64	1262.90	1262.97	0.07	46.88	1.21	36	1261.39	0.0008	0.0011	0.0010
1973	270	5	56.64	1262.88	1262.94	0.06	52.68	1.08	49	1261.17	0.0008	0.0008	0.0008
1973	319	6	56.64	1262.83	1262.90	0.06	50.84	1.11	93	1261.20	0.0019	0.0008	0.0014
1973	412	7	56.64	1262.48	1262.72	0.24	26.68	2.16	51	1261.00	0.0045	0.0019	0.0032
1973	463	8	56.64	1262.42	1262.49	0.07	48.58	1.19	102	1260.56	0.0006	0.0045	0.0025
1973	565	9	56.64	1262.34	1262.43	0.08	46.50	1.30	140	1259.70	0.0009	0.0006	0.0008
1973	705	10	56.64	1262.18	1262.30	0.12	36.43	1.55	89	1260.34	0.0028	0.0009	0.0019
1973	794	10.1	56.64	1261.73	1262.05	0.32	22.73	2.49	49	1260.18	0.0057	0.0028	0.0043
1973	843	10.2	56.64	1261.64	1261.77	0.12	36.34	1.56	102	1259.71	0.0013	0.0057	0.0035
1973	945	11	56.64	1261.51	1261.64	0.13	35.69	1.59	105	1260.00	0.0015	0.0013	0.0014
1973	1050	12	56.64	1261.39	1261.48	0.09	43.12	1.31	136	1259.90	0.0010	0.0015	0.0012
1973	1186	13	56.64	1261.31	1261.35	0.04	61.91	0.91	41	1259.61	0.0007	0.0010	0.0008
1973	1227	19	56.64	1261.25	1261.32	0.07	49.55	1.14	120	1259.50	0.0018	0.0007	0.0012
1973	1347	20	56.64	1260.90	1261.11	0.22	27.51	2.06	75	1259.29	0.0028	0.0018	0.0023
1973	1422	21	56.64	1260.81	1260.90	0.09	42.73	1.33	75	1259.30	0.0015	0.0028	0.0021
1973	1497	22	56.64	1260.69	1260.79	0.10	41.42	1.37	50	1259.10	0.0014	0.0015	0.0014
1973	1547	23	56.64	1260.65	1260.72	0.07	48.35	1.17	0	1258.82		0.0014	0.0014
1974	0	1	56.64	1263.03	1263.13	0.11	39.13	1.45	125	1261.60	0.0014		0.0014
1974	125	2	56.64	1262.89	1262.96	0.06	50.93	1.11	82	1261.48	0.0013	0.0014	0.0014
1974	207	3	56.64	1262.78	1262.85	0.07	48.36	1.17	27	1261.22	0.0015	0.0013	0.0014
1974	234	4	56.64	1262.70	1262.81	0.10	39.70	1.43	36	1261.39	0.0017	0.0015	0.0016
1974	270	5	56.64	1262.66	1262.75	0.08	43.89	1.29	49	1261.17	0.0016	0.0017	0.0016
1974	319	6	56.64	1262.57	1262.67	0.10	40.41	1.40	47	1261.20	0.0028	0.0016	0.0022
1974	366	14	24.65	1262.46	1262.54	0.08	22.49	1.31	32	1260.80	0.0031	0.0028	0.0029
1974	398	15	24.65	1262.37	1262.44	0.07	21.06	1.33	13	1260.78	0.0031	0.0031	0.0031
1974	411	16	24.65	1262.31	1262.40	0.08	22.50	1.39	15	1260.09	0.0160	0.0031	0.0095
1974	426	17	24.65	1261.53	1262.16	0.63	6.98	3.53	16	1259.45	0.0444	0.0160	0.0302
1974	442	18	24.65	1261.40	1261.45	0.05	25.28	1.07	54	1259.16	0.0024	0.0444	0.0234
1974	496	19	56.64	1261.25	1261.32	0.07	49.55	1.14	120	1259.50	0.0018	0.0024	0.0021
1974	616	20	56.64	1260.90	1261.11	0.22	27.51	2.06	75	1259.29	0.0028	0.0018	0.0023
1974	691	21	56.64	1260.81	1260.90	0.09	42.73	1.33	75	1259.30	0.0015	0.0028	0.0021
1974	766	22	56.64	1260.69	1260.79	0.10	41.42	1.37	50	1259.10	0.0014	0.0015	0.0014
1974	816	23	56.64	1260.65	1260.72	0.07	48.35	1.17	0	1258.82		0.0014	0.0014
1974	319	96	56.64	1262.57	1262.67	0.10	40.27	1.41	93	1261.20	0.0040	0.0016	0.0028
1974	412	7	31.99	1262.06	1262.30	0.24	14.77	2.17	51	1261.00	0.0057	0.0040	0.0048
1974	463	8	31.99	1261.96	1262.01	0.05	32.85	0.99	102	1260.56	0.0006	0.0057	0.0031
1974	565	9	31.99	1261.89	1261.95	0.06	30.49	1.05	140	1259.70	0.0008	0.0006	0.0007
1974	705	10	31.99	1261.77	1261.84	0.07	26.50	1.21	89	1260.34	0.0018	0.0008	0.0013
1974	794	10.1	31.99	1261.52	1261.68	0.16	18.08	1.77	49	1260.18	0.0031	0.0018	0.0024
1974	843	10.2	31.99	1261.47	1261.53	0.05	31.73	1.01	102	1259.71	0.0007	0.0031	0.0019

56.64 cms (2000 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1974	945	11	31.99	1261.42	1261.46	0.05	32.75	0.98	105	1260.00	0.0006	0.0007	0.0006
1974	1050	12	31.99	1261.37	1261.40	0.03	42.38	0.75	136	1259.90	0.0003	0.0006	0.0004
1974	1186	13	31.99	1261.35	1261.36	0.01	63.73	0.50	41	1259.61	0.0010	0.0003	0.0006
1974	1227	-19	56.64	1261.25	1261.32	0.07	49.71	1.14	120	1259.50	0.0018	0.0010	0.0014
1990	0	1	56.64	1262.99	1263.11	0.11	38.16	1.48	125	1261.60	0.0018		0.0018
1990	125	2	56.64	1262.81	1262.88	0.07	47.08	1.20	82	1261.48	0.0020	0.0018	0.0019
1990	207	3	56.64	1262.63	1262.72	0.09	42.40	1.34	27	1261.22	0.0022	0.0020	0.0021
1990	234	4	56.64	1262.55	1262.66	0.11	38.83	1.46	36	1261.25	0.0017	0.0022	0.0019
1990	270	5	56.64	1262.51	1262.60	0.09	43.62	1.30	49	1261.00	0.0014	0.0017	0.0015
1990	319	6	56.64	1262.44	1262.53	0.09	43.03	1.32	47	1260.99	0.0026	0.0014	0.0020
1990	366	14	53.01	1262.29	1262.41	0.11	35.28	1.50	32	1260.53	0.0059	0.0026	0.0042
1990	398	15	53.01	1262.01	1262.22	0.21	26.05	2.04	13	1260.42	0.0100	0.0059	0.0080
1990	411	16	53.01	1261.99	1262.09	0.10	37.47	1.41	15	1259.49	0.0093	0.0100	0.0097
1990	426	17	53.01	1261.59	1261.95	0.36	19.91	2.66	16	1258.89	0.0131	0.0093	0.0112
1990	442	18	53.01	1261.71	1261.74	0.03	64.22	0.83	54	1258.31	0.0007	0.0131	0.0069
1990	496	19	56.64	1261.63	1261.70	0.07	48.46	1.17	120	1259.90	0.0009	0.0007	0.0008
1990	616	20	56.64	1261.51	1261.59	0.08	45.77	1.25	75	1259.29	0.0008	0.0009	0.0009
1990	691	21	56.64	1261.47	1261.53	0.06	50.44	1.12	75	1259.80	0.0011	0.0008	0.0009
1990	766	22	56.64	1261.37	1261.45	0.08	45.44	1.25	50	1259.70	0.0010	0.0011	0.0010
1990	816	23	56.64	1261.33	1261.40	0.07	48.87	1.16	0	1259.51		0.0010	0.0010
1990	319	96	56.64	1262.44	1262.53	0.09	42.52	1.33	93	1260.99	0.0051	0.0014	0.0032
1990	412	7	3.63	1262.06	1262.06	0.01	11.17	0.33	51	1261.00	0.0014	0.0051	0.0032
1990	463	8	3.63	1261.99	1261.99	0.00	19.39	0.19	102	1260.95	0.0009	0.0014	0.0011
1990	565	9	3.63	1261.90	1261.90	0.00	14.77	0.25	140	1260.86	0.0006	0.0009	0.0007
1990	705	10	3.63	1261.82	1261.82	0.00	14.90	0.24	89	1260.72	0.0003	0.0006	0.0005
1990	794	10.1	3.63	1261.79	1261.79	0.00	21.12	0.17	49	1260.21	0.0000	0.0003	0.0002
1990	843	10.2	3.63	1261.79	1261.79	0.00	18.84	0.19	102	1260.43	0.0002	0.0000	0.0001
1990	945	11	3.63	1261.77	1261.77	0.00	19.58	0.19	105	1260.76	0.0002	0.0002	0.0002
1990	1050	12	3.63	1261.75	1261.75	0.00	23.69	0.15	136	1260.94	0.0001	0.0002	0.0001
1990	1186	13	3.63	1261.74	1261.74	0.00	31.30	0.12	41	1260.51	0.0010	0.0001	0.0005
1990	1227	-19	56.64	1261.63	1261.70	0.07	48.51	1.17	120	1259.90	0.0009	0.0010	0.0009

84.96 cms (3000 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1973	0	1	84.96	1263.49	1263.60	0.11	57.91	1.47	125	1261.60	0.0010		0.0010
1973	125	2	84.96	1263.41	1263.47	0.07	74.81	1.14	82	1261.48	0.0009	0.0010	0.0009
1973	207	3	84.96	1263.33	1263.40	0.08	70.04	1.22	27	1261.22	0.0011	0.0009	0.0010
1973	234	4	84.96	1263.27	1263.37	0.10	60.90	1.40	36	1261.39	0.0008	0.0011	0.0010
1973	270	5	84.96	1263.26	1263.34	0.08	68.54	1.25	49	1261.17	0.0008	0.0008	0.0008
1973	319	6	84.96	1263.21	1263.30	0.08	66.49	1.28	93	1261.20	0.0018	0.0008	0.0013
1973	412	7	84.96	1262.87	1263.13	0.26	38.45	2.28	51	1261.00	0.0039	0.0018	0.0029
1973	463	8	84.96	1262.83	1262.93	0.09	63.82	1.36	102	1260.56	0.0007	0.0039	0.0023
1973	565	9	84.96	1262.75	1262.86	0.11	63.37	1.48	140	1259.70	0.0011	0.0007	0.0009
1973	705	10	84.96	1262.54	1262.71	0.17	46.13	1.85	89	1260.34	0.0031	0.0011	0.0021
1973	794	10.1	84.96	1262.05	1262.43	0.38	31.05	2.74	49	1260.18	0.0059	0.0031	0.0045
1973	843	10.2	84.96	1261.96	1262.14	0.18	45.33	1.87	102	1259.71	0.0014	0.0059	0.0036
1973	945	11	84.96	1261.83	1262.00	0.17	46.88	1.81	105	1260.00	0.0015	0.0014	0.0014
1973	1050	12	84.96	1261.72	1261.84	0.12	55.79	1.52	136	1259.90	0.0010	0.0015	0.0013
1973	1186	13	84.96	1261.64	1261.70	0.06	77.37	1.10	41	1259.61	0.0007	0.0010	0.0009
1973	1227	19	84.96	1261.59	1261.67	0.08	66.86	1.27	120	1259.50	0.0017	0.0007	0.0012
1973	1347	20	84.96	1261.17	1261.47	0.30	35.06	2.43	75	1259.29	0.0028	0.0017	0.0022
1973	1422	21	84.96	1261.15	1261.26	0.11	56.87	1.49	75	1259.30	0.0013	0.0028	0.0021
1973	1497	22	84.96	1261.03	1261.16	0.13	53.54	1.59	50	1259.10	0.0014	0.0013	0.0014
1973	1547	23	84.96	1260.99	1261.09	0.09	62.23	1.37	0	1258.82		0.0014	0.0014
1974	0	1	84.96	1263.33	1263.47	0.14	51.21	1.66	125	1261.60	0.0014		0.0014
1974	125	2	84.96	1263.21	1263.29	0.09	65.47	1.30	82	1261.48	0.0013	0.0014	0.0014
1974	207	3	84.96	1263.08	1263.18	0.10	60.19	1.41	27	1261.22	0.0019	0.0013	0.0016
1974	234	4	84.96	1262.98	1263.13	0.15	49.84	1.70	36	1261.39	0.0019	0.0019	0.0019
1974	270	5	84.96	1262.94	1263.06	0.12	55.24	1.54	49	1261.17	0.0016	0.0019	0.0018
1974	319	6	84.96	1262.83	1262.98	0.14	50.92	1.67	47	1261.20	0.0034	0.0016	0.0025
1974	366	14	31.33	1262.75	1262.82	0.07	30.25	1.25	32	1260.80	0.0022	0.0034	0.0028
1974	398	15	31.33	1262.69	1262.75	0.06	28.60	1.22	13	1260.78	0.0015	0.0022	0.0019
1974	411	16	31.33	1262.67	1262.73	0.06	31.76	1.26	15	1260.09	0.0160	0.0015	0.0088
1974	426	17	31.33	1261.76	1262.49	0.73	8.27	3.79	16	1259.45	0.0469	0.0160	0.0314
1974	442	18	31.33	1261.70	1261.74	0.05	34.94	1.07	54	1259.16	0.0013	0.0469	0.0241
1974	496	19	84.96	1261.59	1261.67	0.08	66.86	1.27	120	1259.50	0.0017	0.0013	0.0015
1974	616	20	84.96	1261.17	1261.47	0.30	35.06	2.43	75	1259.29	0.0028	0.0017	0.0022
1974	691	21	84.96	1261.15	1261.26	0.11	56.87	1.49	75	1259.30	0.0013	0.0028	0.0021
1974	766	22	84.96	1261.03	1261.16	0.13	53.54	1.59	50	1259.10	0.0014	0.0013	0.0014
1974	816	23	84.96	1260.99	1261.09	0.09	62.23	1.37	0	1258.82		0.0014	0.0014
1974	319	96	84.96	1262.83	1262.97	0.14	51.25	1.66	93	1261.20	0.0031	0.0016	0.0024
1974	412	7	53.63	1262.45	1262.68	0.23	25.65	2.13	51	1261.00	0.0043	0.0031	0.0037
1974	463	8	53.63	1262.39	1262.46	0.07	47.29	1.15	102	1260.56	0.0007	0.0043	0.0025
1974	565	9	53.63	1262.31	1262.39	0.08	45.20	1.26	140	1259.70	0.0009	0.0007	0.0008
1974	705	10	53.63	1262.16	1262.27	0.11	35.96	1.49	89	1260.34	0.0019	0.0009	0.0014
1974	794	10.1	53.63	1261.89	1262.10	0.21	26.43	2.03	49	1260.18	0.0037	0.0019	0.0028
1974	843	10.2	53.63	1261.83	1261.92	0.08	41.58	1.29	102	1259.71	0.0008	0.0037	0.0022

84.96 cms (3000 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1974	945	11	53.63	1261.77	1261.84	0.07	44.86	1.20	105	1260.00	0.0007	0.0008	0.0007
1974	1050	12	53.63	1261.72	1261.77	0.05	55.81	0.96	136	1259.90	0.0004	0.0007	0.0006
1974	1186	13	53.63	1261.69	1261.71	0.02	79.74	0.67	41	1259.61	0.0010	0.0004	0.0007
1974	1227	-19	84.96	1261.59	1261.67	0.08	67.19	1.26	120	1259.50	0.0017	0.0010	0.0013
1990	0	1	84.96	1263.32	1263.46	0.14	51.21	1.66	125	1261.60	0.0017		0.0017
1990	125	2	84.96	1263.16	1263.25	0.09	63.27	1.34	82	1261.48	0.0017	0.0017	0.0017
1990	207	3	84.96	1262.99	1263.11	0.11	56.75	1.50	27	1261.22	0.0022	0.0017	0.0020
1990	234	4	84.96	1262.91	1263.05	0.14	51.71	1.64	36	1261.25	0.0017	0.0022	0.0019
1990	270	5	84.96	1262.88	1262.99	0.11	58.27	1.46	49	1261.00	0.0014	0.0017	0.0015
1990	319	6	84.96	1262.81	1262.92	0.11	57.64	1.47	47	1260.99	0.0023	0.0014	0.0019
1990	366	14	75	1262.67	1262.81	0.14	45.23	1.66	32	1260.53	0.0050	0.0023	0.0037
1990	398	15	75	1262.43	1262.65	0.23	35.57	2.11	13	1260.42	0.0085	0.0050	0.0067
1990	411	16	75	1262.41	1262.54	0.13	47.71	1.57	15	1259.49	0.0113	0.0085	0.0099
1990	426	17	75	1261.89	1262.37	0.48	24.33	3.08	16	1258.89	0.0162	0.0113	0.0138
1990	442	18	75	1262.06	1262.11	0.05	76.45	0.98	54	1258.31	0.0007	0.0162	0.0085
1990	496	19	84.96	1261.99	1262.07	0.08	67.40	1.26	120	1259.90	0.0008	0.0007	0.0008
1990	616	20	84.96	1261.85	1261.97	0.12	56.09	1.54	75	1259.29	0.0011	0.0008	0.0009
1990	691	21	84.96	1261.80	1261.89	0.09	64.50	1.32	75	1259.80	0.0011	0.0011	0.0011
1990	766	22	84.96	1261.70	1261.81	0.11	57.55	1.48	50	1259.70	0.0012	0.0011	0.0011
1990	816	23	84.96	1261.66	1261.75	0.09	62.83	1.36	0	1259.51		0.0012	0.0012
1990	319	96	84.96	1262.81	1262.93	0.11	57.09	1.49	93	1260.99	0.0045	0.0014	0.0030
1990	412	7	9.96	1262.50	1262.51	0.01	23.41	0.43	51	1261.00	0.0014	0.0045	0.0029
1990	463	8	9.96	1262.44	1262.44	0.00	34.54	0.29	102	1260.95	0.0010	0.0014	0.0012
1990	565	9	9.96	1262.33	1262.34	0.01	30.23	0.36	140	1260.86	0.0006	0.0010	0.0008
1990	705	10	9.96	1262.24	1262.25	0.01	25.07	0.40	89	1260.72	0.0006	0.0006	0.0006
1990	794	10.1	9.96	1262.19	1262.20	0.00	32.13	0.31	49	1260.21	0.0002	0.0006	0.0004
1990	843	10.2	9.96	1262.18	1262.19	0.01	30.47	0.33	102	1260.43	0.0003	0.0002	0.0002
1990	945	11	9.96	1262.16	1262.16	0.00	33.77	0.30	105	1260.76	0.0002	0.0003	0.0002
1990	1050	12	9.96	1262.14	1262.14	0.00	38.67	0.26	136	1260.94	0.0001	0.0002	0.0002
1990	1186	13	9.96	1262.12	1262.12	0.00	49.36	0.20	41	1260.51	0.0012	0.0001	0.0007
1990	1227	-19	84.96	1261.99	1262.07	0.08	67.22	1.26	120	1259.90	0.0008	0.0012	0.0010

113.28 cms (4000 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1973	0	1	113.28	1263.80	1263.93	0.13	71.26	1.59	125	1261.60	0.0010		0.0010
1973	125	2	113.28	1263.73	1263.81	0.08	90.02	1.26	82	1261.48	0.0010	0.0010	0.0010
1973	207	3	113.28	1263.64	1263.73	0.10	83.45	1.37	27	1261.22	0.0007	0.0010	0.0009
1973	234	4	113.28	1263.58	1263.71	0.12	73.24	1.56	36	1261.39	0.0011	0.0007	0.0009
1973	270	5	113.28	1263.57	1263.67	0.10	82.66	1.39	49	1261.17	0.0008	0.0011	0.0010
1973	319	6	113.28	1263.52	1263.63	0.10	81.24	1.41	93	1261.20	0.0017	0.0008	0.0013
1973	412	7	113.28	1263.17	1263.47	0.30	48.31	2.44	51	1261.00	0.0039	0.0017	0.0028
1973	463	8	113.28	1263.15	1263.27	0.11	76.66	1.52	102	1260.56	0.0008	0.0039	0.0024
1973	565	9	113.28	1263.06	1263.19	0.13	76.15	1.66	140	1259.70	0.0012	0.0008	0.0010
1973	705	10	113.28	1262.79	1263.02	0.23	55.53	2.13	89	1260.34	0.0030	0.0012	0.0021
1973	794	10.1	113.28	1262.33	1262.75	0.42	40.66	2.87	49	1260.18	0.0057	0.0030	0.0044
1973	843	10.2	113.28	1262.25	1262.47	0.22	53.89	2.10	102	1259.71	0.0015	0.0057	0.0036
1973	945	11	113.28	1262.12	1262.32	0.20	57.48	1.98	105	1260.00	0.0015	0.0015	0.0015
1973	1050	12	113.28	1262.01	1262.16	0.14	67.20	1.69	136	1259.90	0.0011	0.0015	0.0013
1973	1186	13	113.28	1261.94	1262.01	0.08	91.40	1.24	41	1259.61	0.0007	0.0011	0.0009
1973	1227	19	113.28	1261.89	1261.98	0.10	82.65	1.37	120	1259.50	0.0016	0.0007	0.0012
1973	1347	20	113.28	1261.43	1261.79	0.36	43.01	2.66	75	1259.29	0.0028	0.0016	0.0022
1973	1422	21	113.28	1261.45	1261.58	0.13	69.58	1.63	75	1259.30	0.0013	0.0028	0.0021
1973	1497	22	113.28	1261.32	1261.48	0.16	64.24	1.76	50	1259.10	0.0014	0.0013	0.0014
1973	1547	23	113.28	1261.29	1261.41	0.12	74.54	1.52	0	1258.82		0.0014	0.0014
1974	0	1	113.28	1263.61	1263.77	0.16	62.98	1.80	125	1261.60	0.0014		0.0014
1974	125	2	113.28	1263.49	1263.60	0.11	78.68	1.44	82	1261.48	0.0015	0.0014	0.0014
1974	207	3	113.28	1263.35	1263.48	0.13	71.30	1.59	27	1261.22	0.0019	0.0015	0.0017
1974	234	4	113.28	1263.25	1263.43	0.18	59.80	1.90	36	1261.39	0.0019	0.0019	0.0019
1974	270	5	113.28	1263.21	1263.36	0.15	66.46	1.71	49	1261.17	0.0018	0.0019	0.0019
1974	319	6	113.28	1263.10	1263.27	0.17	62.03	1.83	47	1261.20	0.0036	0.0018	0.0027
1974	366	14	37.9	1263.05	1263.10	0.05	41.58	1.16	32	1260.80	0.0016	0.0036	0.0026
1974	398	15	37.9	1263.00	1263.05	0.06	35.87	1.16	13	1260.78	0.0015	0.0016	0.0016
1974	411	16	37.9	1262.98	1263.03	0.05	40.84	1.18	15	1260.09	0.0173	0.0015	0.0094
1974	426	17	37.9	1261.96	1262.77	0.81	9.49	3.99	16	1259.45	0.0463	0.0173	0.0318
1974	442	18	37.9	1261.98	1262.03	0.05	44.61	1.13	54	1259.16	0.0009	0.0463	0.0236
1974	496	19	113.28	1261.89	1261.98	0.10	82.65	1.37	120	1259.50	0.0016	0.0009	0.0013
1974	616	20	113.28	1261.43	1261.79	0.36	43.01	2.66	75	1259.29	0.0028	0.0016	0.0022
1974	691	21	113.28	1261.45	1261.58	0.13	69.58	1.63	75	1259.30	0.0013	0.0028	0.0021
1974	766	22	113.28	1261.32	1261.48	0.16	64.24	1.76	50	1259.10	0.0014	0.0013	0.0014
1974	816	23	113.28	1261.29	1261.41	0.12	74.54	1.52	0	1258.82		0.0014	0.0014
1974	319	96	113.28	1263.10	1263.27	0.17	62.30	1.82	93	1261.20	0.0028	0.0018	0.0023
1974	412	7	75.38	1262.77	1263.01	0.25	35.02	2.21	51	1261.00	0.0039	0.0028	0.0034
1974	463	8	75.38	1262.72	1262.81	0.08	59.52	1.30	102	1260.56	0.0007	0.0039	0.0023
1974	565	9	75.38	1262.65	1262.74	0.10	58.89	1.40	140	1259.70	0.0009	0.0007	0.0008
1974	705	10	75.38	1262.46	1262.61	0.15	43.77	1.73	89	1260.34	0.0020	0.0009	0.0015
1974	794	10.1	75.38	1262.19	1262.43	0.24	35.08	2.16	49	1260.18	0.0037	0.0020	0.0028
1974	843	10.2	75.38	1262.14	1262.25	0.11	50.69	1.49	102	1259.71	0.0008	0.0037	0.0022

113.28 cms (4000 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1974	945	11	75.38	1262.08	1262.17	0.09	55.99	1.35	105	1260.00	0.0008	0.0008	0.0008
1974	1050	12	75.38	1262.03	1262.09	0.06	67.88	1.11	136	1259.90	0.0004	0.0008	0.0006
1974	1186	13	75.38	1262.00	1262.03	0.03	94.10	0.80	41	1259.61	0.0012	0.0004	0.0008
1974	1227	-19	113.28	1261.89	1261.98	0.10	83.00	1.37	120	1259.50	0.0016	0.0012	0.0014
1990	0	1	113.28	1263.63	1263.79	0.16	63.71	1.78	125	1261.60	0.0016		0.0016
1990	125	2	113.28	1263.48	1263.59	0.11	78.10	1.45	82	1261.48	0.0017	0.0016	0.0017
1990	207	3	113.28	1263.31	1263.45	0.14	69.45	1.63	27	1261.22	0.0022	0.0017	0.0020
1990	234	4	113.28	1263.23	1263.39	0.16	63.53	1.79	36	1261.25	0.0017	0.0022	0.0019
1990	270	5	113.28	1263.21	1263.33	0.13	71.77	1.58	49	1261.00	0.0012	0.0017	0.0014
1990	319	6	113.28	1263.15	1263.27	0.13	71.42	1.59	47	1260.99	0.0021	0.0012	0.0017
1990	366	14	95.8	1263.02	1263.17	0.15	57.82	1.74	32	1260.53	0.0044	0.0021	0.0033
1990	398	15	95.8	1262.80	1263.03	0.24	44.26	2.16	13	1260.42	0.0077	0.0044	0.0060
1990	411	16	95.8	1262.79	1262.93	0.14	57.90	1.65	15	1259.49	0.0133	0.0077	0.0105
1990	426	17	95.8	1262.15	1262.73	0.58	28.38	3.38	16	1258.89	0.0187	0.0133	0.0160
1990	442	18	95.8	1262.37	1262.43	0.06	87.15	1.10	54	1258.31	0.0007	0.0187	0.0097
1990	496	19	113.28	1262.29	1262.39	0.09	83.57	1.36	120	1259.90	0.0009	0.0007	0.0008
1990	616	20	113.28	1262.13	1262.28	0.16	65.35	1.77	75	1259.29	0.0011	0.0009	0.0010
1990	691	21	113.28	1262.09	1262.20	0.11	77.01	1.47	75	1259.80	0.0011	0.0011	0.0011
1990	766	22	113.28	1261.98	1262.12	0.14	67.96	1.67	50	1259.70	0.0012	0.0011	0.0011
1990	816	23	113.28	1261.94	1262.06	0.12	75.29	1.52	0	1259.51		0.0012	0.0012
1990	319	96	113.28	1263.15	1263.27	0.13	71.06	1.59	93	1260.99	0.0043	0.0012	0.0028
1990	412	7	17.48	1262.85	1262.87	0.01	34.45	0.53	51	1261.00	0.0014	0.0043	0.0028
1990	463	8	17.48	1262.80	1262.80	0.01	47.91	0.37	102	1260.95	0.0010	0.0014	0.0012
1990	565	9	17.48	1262.69	1262.70	0.01	44.60	0.44	140	1260.86	0.0007	0.0010	0.0008
1990	705	10	17.48	1262.59	1262.60	0.01	34.94	0.51	89	1260.72	0.0007	0.0007	0.0007
1990	794	10.1	17.48	1262.53	1262.54	0.01	45.74	0.41	49	1260.21	0.0002	0.0007	0.0004
1990	843	10.2	17.48	1262.52	1262.53	0.01	40.95	0.43	102	1260.43	0.0003	0.0002	0.0002
1990	945	11	17.48	1262.49	1262.50	0.01	46.42	0.38	105	1260.76	0.0003	0.0003	0.0003
1990	1050	12	17.48	1262.47	1262.47	0.01	51.99	0.34	136	1260.94	0.0001	0.0003	0.0002
1990	1186	13	17.48	1262.44	1262.45	0.00	65.55	0.27	41	1260.51	0.0015	0.0001	0.0008
1990	1227	-19	113.28	1262.29	1262.39	0.09	83.44	1.36	120	1259.90	0.0009	0.0015	0.0012

141.60 cms (5000 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1973	0	1	141.6	1264.07	1264.22	0.15	84.08	1.70	125	1261.60	0.0010		0.0010
1973	125	2	141.6	1264.01	1264.10	0.09	104.76	1.37	82	1261.48	0.0009	0.0010	0.0009
1973	207	3	141.6	1263.91	1264.03	0.11	95.54	1.51	27	1261.22	0.0011	0.0009	0.0010
1973	234	4	141.6	1263.85	1264.00	0.15	84.13	1.71	36	1261.39	0.0011	0.0011	0.0011
1973	270	5	141.6	1263.84	1263.96	0.12	95.52	1.52	49	1261.17	0.0008	0.0011	0.0010
1973	319	6	141.6	1263.80	1263.92	0.12	94.78	1.53	93	1261.20	0.0017	0.0008	0.0013
1973	412	7	141.6	1263.42	1263.76	0.34	56.80	2.62	51	1261.00	0.0041	0.0017	0.0029
1973	463	8	141.6	1263.41	1263.55	0.14	87.03	1.68	102	1260.56	0.0008	0.0041	0.0025
1973	565	9	141.6	1263.31	1263.47	0.16	86.67	1.84	140	1259.70	0.0014	0.0008	0.0011
1973	705	10	141.6	1262.98	1263.27	0.29	63.87	2.40	89	1260.34	0.0029	0.0014	0.0022
1973	794	10.1	141.6	1262.59	1263.01	0.42	51.42	2.92	49	1260.18	0.0049	0.0029	0.0039
1973	843	10.2	141.6	1262.51	1262.77	0.27	61.98	2.28	102	1259.71	0.0017	0.0049	0.0033
1973	945	11	141.6	1262.38	1262.60	0.23	67.39	2.12	105	1260.00	0.0015	0.0017	0.0016
1973	1050	12	141.6	1262.27	1262.44	0.17	77.61	1.82	136	1259.90	0.0010	0.0015	0.0013
1973	1186	13	141.6	1262.20	1262.30	0.09	104.23	1.37	41	1259.61	0.0007	0.0010	0.0009
1973	1227	19	141.6	1262.16	1262.27	0.11	97.39	1.46	120	1259.50	0.0016	0.0007	0.0012
1973	1347	20	141.6	1261.67	1262.08	0.41	50.42	2.86	75	1259.29	0.0028	0.0016	0.0022
1973	1422	21	141.6	1261.72	1261.87	0.16	81.01	1.75	75	1259.30	0.0013	0.0028	0.0021
1973	1497	22	141.6	1261.58	1261.77	0.19	73.81	1.92	50	1259.10	0.0016	0.0013	0.0015
1973	1547	23	141.6	1261.55	1261.69	0.14	85.67	1.65	0	1258.82		0.0016	0.0016
1974	0	1	141.6	1263.85	1264.04	0.19	73.67	1.92	125	1261.60	0.0014		0.0014
1974	125	2	141.6	1263.74	1263.86	0.12	90.62	1.57	82	1261.48	0.0015	0.0014	0.0015
1974	207	3	141.6	1263.59	1263.74	0.16	81.46	1.76	27	1261.22	0.0019	0.0015	0.0017
1974	234	4	141.6	1263.47	1263.69	0.22	68.95	2.07	36	1261.39	0.0019	0.0019	0.0019
1974	270	5	141.6	1263.45	1263.62	0.18	76.96	1.86	49	1261.17	0.0018	0.0019	0.0019
1974	319	6	141.6	1263.34	1263.53	0.20	71.97	1.97	47	1261.20	0.0040	0.0018	0.0029
1974	366	14	43.7	1263.30	1263.34	0.05	51.97	1.09	32	1260.80	0.0012	0.0040	0.0026
1974	398	15	43.7	1263.24	1263.30	0.06	41.62	1.14	13	1260.78	0.0015	0.0012	0.0014
1974	411	16	43.7	1263.23	1263.28	0.05	48.18	1.14	15	1260.09	0.0180	0.0015	0.0098
1974	426	17	43.7	1262.14	1263.01	0.87	10.57	4.14	16	1259.45	0.0431	0.0180	0.0306
1974	442	18	43.7	1262.27	1262.32	0.04	54.51	1.07	54	1259.16	0.0009	0.0431	0.0220
1974	496	19	141.6	1262.16	1262.27	0.11	97.39	1.46	120	1259.50	0.0016	0.0009	0.0013
1974	616	20	141.6	1261.67	1262.08	0.41	50.42	2.86	75	1259.29	0.0028	0.0016	0.0022
1974	691	21	141.6	1261.72	1261.87	0.16	81.01	1.75	75	1259.30	0.0013	0.0028	0.0021
1974	766	22	141.6	1261.58	1261.77	0.19	73.81	1.92	50	1259.10	0.0016	0.0013	0.0015
1974	816	23	141.6	1261.55	1261.69	0.14	85.67	1.65	0	1258.82		0.0016	0.0016
1974	319	96	141.6	1263.34	1263.54	0.20	72.35	1.96	93	1261.20	0.0027	0.0018	0.0023
1974	412	7	97.9	1263.02	1263.29	0.27	43.37	2.34	51	1261.00	0.0037	0.0027	0.0032
1974	463	8	97.9	1263.00	1263.10	0.10	70.38	1.43	102	1260.56	0.0007	0.0037	0.0022
1974	565	9	97.9	1262.92	1263.03	0.11	70.21	1.55	140	1259.70	0.0011	0.0007	0.0009
1974	705	10	97.9	1262.68	1262.88	0.20	51.26	1.96	89	1260.34	0.0018	0.0011	0.0014
1974	794	10.1	97.9	1262.47	1262.72	0.25	46.27	2.22	49	1260.18	0.0033	0.0018	0.0025
1974	843	10.2	97.9	1262.42	1262.56	0.14	59.34	1.65	102	1259.71	0.0009	0.0033	0.0021

141.60 cms (5000 cfs) Results

Scenario	Distance Downstream (m)	Cross Section	Discharge (cms)	Water Surface (m)	Energy Grade (m)	Velocity Head (m)	Area (sq.m)	Channel Velocity (m/sec)	Reach Length (m)	Thalweg Elevation (m)	Energy Slope (D/S)	Energy Slope (U/S)	Average Energy Slope
1974	945	11	97.9	1262.36	1262.47	0.11	66.48	1.48	105	1260.00	0.0008	0.0009	0.0008
1974	1050	12	97.9	1262.31	1262.39	0.08	78.92	1.24	136	1259.90	0.0005	0.0008	0.0006
1974	1186	13	97.9	1262.27	1262.32	0.04	107.61	0.92	41	1259.61	0.0012	0.0005	0.0009
1974	1227	-19	141.6	1262.16	1262.27	0.11	97.39	1.46	120	1259.50	0.0016	0.0012	0.0014
1990	0	1	141.6	1263.90	1264.08	0.18	75.41	1.88	125	1261.60	0.0015		0.0015
1990	125	2	141.6	1263.77	1263.89	0.12	92.12	1.54	82	1261.48	0.0017	0.0015	0.0016
1990	207	3	141.6	1263.60	1263.75	0.16	81.66	1.76	27	1261.22	0.0019	0.0017	0.0018
1990	234	4	141.6	1263.51	1263.70	0.19	74.94	1.91	36	1261.25	0.0017	0.0019	0.0018
1990	270	5	141.6	1263.50	1263.64	0.15	84.94	1.69	49	1261.00	0.0012	0.0017	0.0014
1990	319	6	141.6	1263.44	1263.58	0.14	84.76	1.68	47	1260.99	0.0017	0.0012	0.0015
1990	366	14	116.15	1263.35	1263.50	0.15	71.71	1.76	32	1260.53	0.0037	0.0017	0.0027
1990	398	15	116.15	1263.12	1263.38	0.25	51.91	2.24	13	1260.42	0.0085	0.0037	0.0061
1990	411	16	116.15	1263.12	1263.27	0.15	67.57	1.72	15	1259.49	0.0140	0.0085	0.0112
1990	426	17	116.15	1262.38	1263.06	0.68	31.87	3.65	16	1258.89	0.0219	0.0140	0.0179
1990	442	18	116.15	1262.64	1262.71	0.07	96.83	1.21	54	1258.31	0.0007	0.0219	0.0113
1990	496	19	141.6	1262.56	1262.67	0.11	98.37	1.45	120	1259.90	0.0009	0.0007	0.0008
1990	616	20	141.6	1262.37	1262.56	0.19	73.60	1.96	75	1259.29	0.0012	0.0009	0.0011
1990	691	21	141.6	1262.34	1262.47	0.13	89.01	1.60	75	1259.80	0.0011	0.0012	0.0011
1990	766	22	141.6	1262.22	1262.39	0.17	79.09	1.82	50	1259.70	0.0012	0.0011	0.0011
1990	816	23	141.6	1262.19	1262.33	0.14	87.04	1.65	0	1259.51		0.0012	0.0012
1990	319	96	141.6	1263.44	1263.58	0.15	83.94	1.70	93	1260.99	0.0043	0.0012	0.0028
1990	412	7	25.45	1263.16	1263.18	0.02	44.09	0.61	51	1261.00	0.0014	0.0043	0.0028
1990	463	8	25.45	1263.10	1263.11	0.01	60.10	0.43	102	1260.95	0.0011	0.0014	0.0012
1990	565	9	25.45	1262.99	1263.00	0.01	57.03	0.51	140	1260.86	0.0007	0.0011	0.0009
1990	705	10	25.45	1262.89	1262.90	0.02	46.56	0.59	89	1260.72	0.0007	0.0007	0.0007
1990	794	10.1	25.45	1262.83	1262.84	0.01	59.16	0.47	49	1260.21	0.0004	0.0007	0.0005
1990	843	10.2	25.45	1262.81	1262.82	0.01	50.43	0.51	102	1260.43	0.0003	0.0004	0.0004
1990	945	11	25.45	1262.78	1262.79	0.01	57.92	0.45	105	1260.76	0.0003	0.0003	0.0003
1990	1050	12	25.45	1262.76	1262.76	0.01	64.91	0.40	136	1260.94	0.0001	0.0003	0.0002
1990	1186	13	25.45	1262.73	1262.74	0.01	80.97	0.32	41	1260.51	0.0017	0.0001	0.0009
1990	1227	-19	141.6	1262.56	1262.67	0.11	98.22	1.45	120	1259.90	0.0009	0.0017	0.0013

APPENDIX E.

FLOOD FREQUENCY ANALYSIS

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WATSTORE PEAK FLOW FILE RETRIEVAL PGM.  J980 - RUN DATE :  15 NOV 91   12.21.03
PROGRAM LAST REVISED :   3 OCT 83 18.25.23


*** EXPLANATION OF PEAK DATA CODES *****

    DISCHARGE QUALIFICATION CODES:

      1...DISCHARGE IS A MAXIMUM DAILY AVERAGE
      2...DISCHARGE IS AN ESTIMATE
      3...DISCHARGE AFFECTED BY DAM FAILURE
      4...DISCHARGE LESS THAN INDICATED VALUE, WHICH IS MINIMUM RECORDABLE DISCHARGE AT THIS SITE
      5...DISCHARGE AFFECTED TO UNKNOWN DEGREE BY REGULATION OR DIVERSION
      6...DISCHARGE AFFECTED BY REGULATION OR DIVERSION
      7...DISCHARGE IS AN HISTORIC PEAK
      8...DISCHARGE ACTUALLY GREATER THAN INDICATED VALUE
      9...DISCHARGE DUE TO SNOWMELT, HURRICANE, ICE-JAM OR DEBRIS DAM BREAKUP
      A...YEAR OF OCCURRENCE IS UNKNOWN OR NOT EXACT
      B...MONTH OR DAY OF OCCURRENCE IS UNKNOWN OR NOT EXACT
      C...ALL OR PART OF THE RECORD AFFECTED BY URBANIZATION, MINING, AGRICULTURAL CHANGES, CHANNELIZATION, OR OTHER
      D...BASE DISCHARGE CHANGED DURING THIS YEAR
      E...ONLY ANNUAL MAXIMUM PEAK AVAILABLE FOR THIS YEAR

    GAGE HEIGHT QUALIFICATION CODES:

      1...GAGE HEIGHT AFFECTED BY BACKWATER
      2...GAGE HEIGHT NOT THE MAXIMUM FOR THE YEAR
      3...GAGE HEIGHT AT DIFFERENT SITE AND/OR DATUM
      4...GAGE HEIGHT BELOW MINIMUM RECORDABLE ELEVATION
      5...GAGE HEIGHT IS AN ESTIMATE
      6...GAGE DATUM CHANGED DURING THIS YEAR


*** NOTES *****

BASE DISCHARGE (IF REPORTED) MAY NOT BE EFFECTIVE FOR ENTIRE PERIOD OF RECORD; CURRENT VALUE USED.

GAGE DATUM (IF REPORTED) MAY NOT BE EFFECTIVE FOR ENTIRE PERIOD OF RECORD; CURRENT VALUE USED.



RETRIEVAL SPECIFICATIONS FOR REQUEST NUMBER 01 ARE AS FOLLOWS:
M CARD:  M                                                          01
PEAK FLOW RETRIEVAL NUMBER 01 IS FOR ALL WATER YEARS
THE FOLLOWING HAVE BEEN REQUESTED:
.....LONG FORMAT PRINTOUT
.....STANDARD RECORD FORMAT

.....VECTOR FORMAT(FROM X CARD) --XJ407   $JOB
                                --XJ407   $OPTNOBC        RSK1        NOEX

NUMBER OF SITES RETRIEVED:      1
NUMBER OF RECORDS RETRIEVED:      19



END OF RETRIEVAL PROCESSING
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STATION 13310700 S FK SALMON RIVER NR KRASSEL RANGER STATION ID

AGENCY: USGS
STATE: 16
COUNTY: 085
DISTRICT: 16

STATION LOCATOR
LAT. LONG.
445930 1154330

DRAINAGE AREA: 330.00 SQ MI
CONTRIBUTING DRAINAGE AREA: SQ MI
GAGE DATUM: 3750.00 (NGVD)
BASE DISCHARGE: 1500.00 CFS

WATER YEAR	DATE	PEAK DISCHARGE (CFS)	DISCHARGE CODES	GAGE HEIGHT (FT)	GAGE HT CODES	HIGHEST SINCE	MAX GAGE HEIGHT (FT)	DATE	GAGE HT CODES	NUMBER OF PARTIAL PEAKS
1967	05/24/67	3840.00		7.75						2
	05/10/67	1640.00		5.02						
	06/20/67	3430.00		7.29						
1968	06/04/68	2450.00		6.13						0
1969	05/15/69	3740.00		7.38						1
	04/24/69	1840.00		5.35						
1970	06/06/70	4720.00		8.14						3
	05/07/70	1590.00		5.07						
	05/27/70	3830.00		7.41						
	06/28/70	3410.00		7.04						
1971	05/29/71	5070.00		8.47						3
	11/25/70	1990.00		5.62						
	05/13/71	4290.00		7.90						
	06/26/71	4640.00		8.10						
1972	06/10/72	5630.00		8.83						1
	05/18/72	2940.00		6.57						
1973	05/19/73	2460.00		6.08						0
1974	06/17/74	6740.00		10.00						5
	11/12/73	2340.00		5.94						
	01/16/74	4030.00		7.70						
	04/26/74	2230.00		5.80						
	05/09/74	3460.00		7.14						
	06/05/74	5510.00		9.01						
1975	06/07/75	3590.00		7.27						2
	05/17/75	2250.00		5.83						
	07/04/75	2370.00		5.98						
1976	05/11/76	3420.00		7.10						1
	06/11/76	2730.00		6.38						
1977	06/08/77	778.00		3.70						0
1978	06/09/78	3430.00		7.11						1
	05/15/78	2430.00		6.04						
1979	05/27/79	2620.00		6.28						1
	06/05/79	1760.00		5.22						
1980	05/23/80	3550.00		7.23						2
	05/07/80	3080.00		6.75						
	06/22/80	2210.00		5.77						
1981	06/09/81	3560.00		7.11						3
	12/26/80	1550.00		4.87						
	05/02/81	2830.00		6.37						
	05/31/81	2930.00		6.47						
1982	05/26/82	5120.00		8.68						3
	02/22/82	2410.00		6.02						
	05/03/82	2190.00		5.75						
	06/22/82	4680.00		8.29						
1985	05/25/85	2580.00		6.29						2

	06/06/85	1690.00	5.23	
1986	05/21/86	2230.00	5.87	3
	03/08/86	1630.00	5.14	
	04/23/86	1970.00	5.47	
	05/04/86	1700.00	5.18	
1989	05/11/89	2780.00	6.35	3
	04/22/89	1820.00	5.33	
	06/08/89	2220.00	5.76	
	06/15/89	2360.00	5.92	

END OF PROGRAM J980.

PGM J407 VER 3.7
(REV 11/5/81)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.

EXECUTION BEGINNING AT DATE, TIME = 11/15/91 1221

INPUT FORMAT = 1 WATSTORE PEAK FILE RETRIEVAL

EXPLANATION OF PEAK DISCHARGE QUALIFICATION CODES

J407	FILE	MEANING
D	3	DAM FAILURE, NON-RECURRENT FLOW ANOMALY
G	8	DISCHARGE GREATER THAN STATED VALUE
X	3+8	BOTH OF THE ABOVE
L	4	DISCHARGE LESS THAN STATED VALUE
K	6 OR C	KNOWN EFFECT OF REGULATION OR URBANIZATION
H	7	HISTORIC PEAK

REPORT TROUBLE TO WATSTORE USER ASSISTANCE.

J407 -- REVISED FOR USE WITH W.R.C. BULLETIN 17-B. 8/1/81

PEAK FLOW FILE RETRIEVAL VERSION

PRINCIPAL CHANGES INCLUDE --
-- HIGH OUTLIER TEST
-- MORE SENSITIVE LOW OUTLIER TEST
-- STATION SKEW ADJUSTMENT FOR LOW OUTLIERS AND ZERO FLOWS
-- WEIGHTED AVERAGING OF STATION AND GENERALIZED SKEWS IN
INVERSE PROPORTION TO ESTIMATED MEAN SQUARE ERRORS.

FOR DETAILS, SEE WATSTORE USER'S GUIDE, VOL. 4, CH. I (1981 REVISION), SEC. C.

NO CHANGES IN JOB INPUT PREPARATION ARE REQUIRED IN RETRIEVAL MODE
MINOR CHANGES MAY BE REQUIRED IN STANDALONE (CARD INPUT) MODE.

NOTE -- IN STANDALONE MODE (CARD INPUT), A NEW FORMAT IS USED FOR HISTORIC AND OUTLIER INFORMATION. SEE WATSTORE USER'S GUIDE, VOL. 4, CH I. SEC. C. 2. K (1981 REVISION). NO CHANGE IS NEEDED FOR STATIONS HAVING NO HISTORIC/OUTLIER INFORMATION.

NOTE -- IN STANDALONE MODE, USE REGION=140K ON THE EXEC CARD.

NOTE -- SUMMARY OUTPUT IS PRODUCED BY DEFAULT, UNLESS SUPPRESSED BY THE NOBC OPTION. (BCPU IS THE DEFAULT OPTION.) BCPU OUTPUT

ORDINARILY GOES TO A TEMPORARY DATA SET NAMED &&BCCARDS, WHICH IS AVAILABLE TO LATER STEPS OF THE JOB IN WHICH IT WAS CREATED, BUT IS DELETED AT THE END OF THE JOB. TO GET A PERMANENT ONLINE DATA SET, TYPE BCU=ONLINE,BCDS='USERID.DATA.SET.NAME' ON THE EXEC CARD FOR PKWRCA. TO GET ACTUAL PUNCHED CARDS, TYPE BCOUT=SYSOUT INSTEAD. SEE WATSTORE USER'S GUIDE VOL.4, CH.I, SEC. C.2.G & H.

NOTE -- OLD J407 PROGRAM IS STILL AVAILABLE FOR TESTS AND COMPARISONS
TO USE IT, TYPE PROG=J407A ON THE EXEC CARD.

PGM J407 VER 3.7
(REV 11/5/81)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.

RUN-DATE 11/15/91 AT 1221 SEQ 1.0001

OPTIONS IN EFFECT -- PLOT NOBC LGPT NODB PPOS RSK1 NOEX CLIM

STATION - 13310700 /USGS S FK SALMON RIVER NR KRASSEL RANGER STATION ID 1967-1989 13310700 /USGS

INPUT DATA SUMMARY

-- YEARS OF RECORD -- SYSTEMATIC	HISTORIC	HISTORIC PEAKS	GENERALIZED SKEW	STD. ERROR OF GENERAL. SKEW	SKEW OPTION	GAGE BASE DISCHARGE	USER-SET OUTLIER CRITERIA HIGH OUTLIER	LOW OUTLIER
19	0	0	-0.300	--	WRC WEIGHTED	0.0	--	--

********* NOTICE -- PRELIMINARY MACHINE COMPUTATIONS. *********
********* USER RESPONSIBLE FOR ASSESSMENT AND INTERPRETATION. *********

WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE. 0.0
WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED. 1 1095.5
WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE. 7506.1

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE DISCHARGE	FLOOD BASE EXCEEDANCE PROBABILITY	LOGARITHMIC MEAN	LOGARITHMIC STANDARD DEVIATION	LOGARITHMIC SKEW
SYSTEMATIC RECORD	0.0	1.0000	3.5181	0.2027	-1.476
W R C ESTIMATE	1095.5	0.9474	3.5422	0.1439	0.0

ANNUAL FREQUENCY CURVE ORDINATES -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	W R C ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR W R C ESTIMATES LOWER	UPPER
0.9950	--	536.5	--	--	--
0.9900	--	701.3	--	--	--
0.9500	--	1328.3	--	--	--
0.9000	2279.0	1768.9	--	1837.2	2638.5
0.8000	2636.7	2384.8	--	2209.4	3007.0
0.5000	3484.7	3681.7	--	3059.7	3968.6
0.2000	4605.4	4849.5	--	4038.2	5495.9
0.1000	5328.1	5315.8	--	4602.1	6609.6
0.0400	6224.2	5682.4	--	5259.2	8094.8
0.0200	6881.7	5851.6	--	5721.0	9246.3
0.0100	7532.2	5964.7	--	6165.1	10431.1
0.0050	8181.3	6040.9	--	6597.7	11655.1
0.0020	9043.2	6105.4	--	7158.7	13340.0

PGM J407 VER 3.7
(REV 11/5/81)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.

RUN-DATE 11/15/91 AT 1221 SEQ 1.0001

STATION - 13310700 /USGS S FK SALMON RIVER NR KRASSEL RANGER STATION ID 1967-1989 13310700 /USGS

********* NOTICE -- PRELIMINARY MACHINE COMPUTATIONS. *********
********* USER RESPONSIBLE FOR ASSESSMENT AND INTERPRETATION. *********

INPUT DATA LISTING

WATER YEAR	DISCHARGE	CODES
1967	3840.0	
1968	2450.0	
1969	3740.0	
1970	4720.0	
1971	5070.0	
1972	5630.0	
1973	2460.0	
1974	6740.0	
1975	3590.0	
1976	3420.0	
1977	778.0	
1978	3430.0	
1979	2620.0	
1980	3550.0	
1981	3560.0	
1982	5120.0	
1985	2580.0	
1986	2230.0	
1989	2780.0	

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

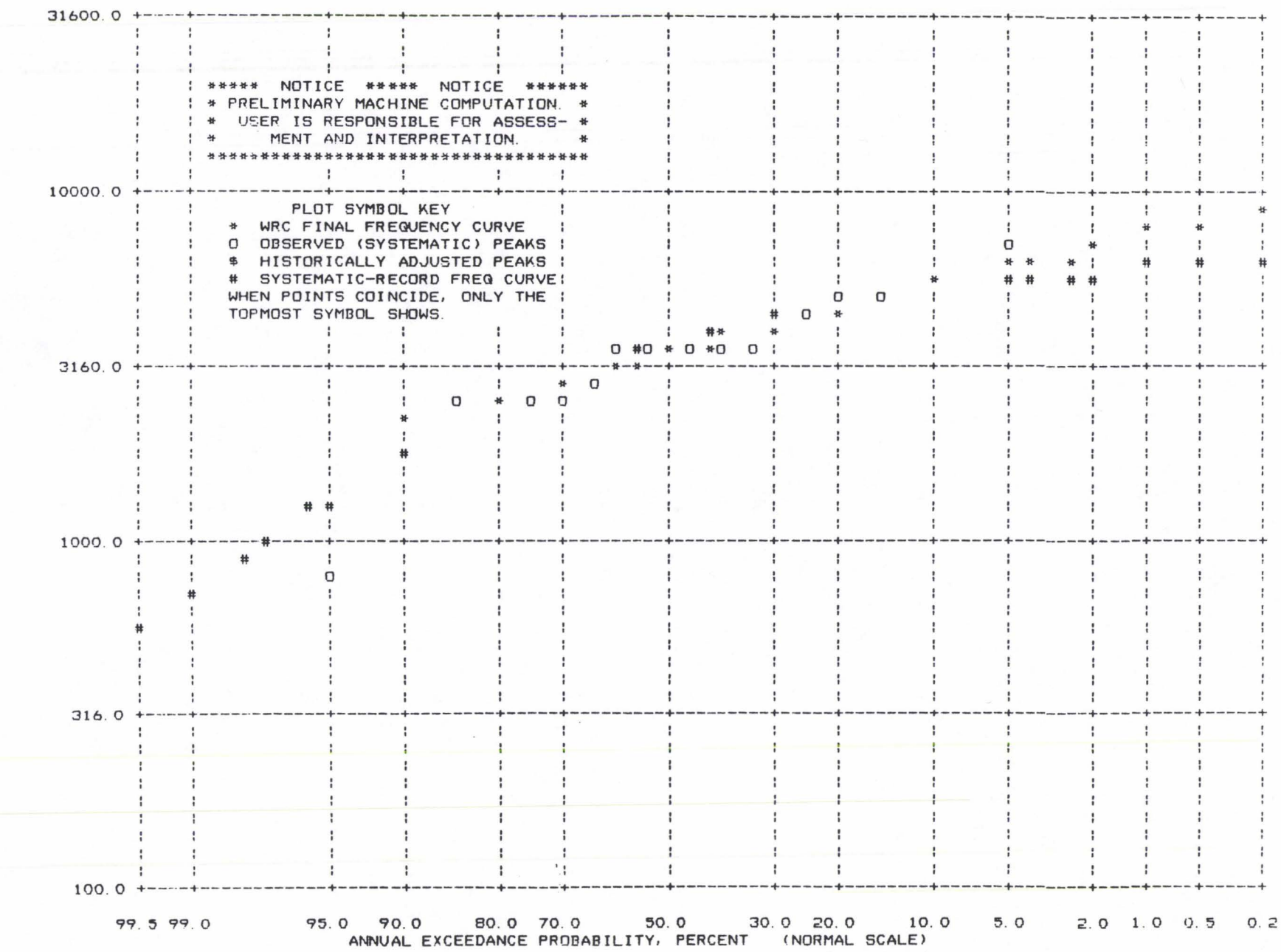
WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	W R C ESTIMATE
1974	6740.0	0.0500	0.0500
1972	5630.0	0.1000	0.1000
1982	5120.0	0.1500	0.1500
1971	5070.0	0.2000	0.2000
1970	4720.0	0.2500	0.2500
1967	3840.0	0.3000	0.3000
1969	3740.0	0.3500	0.3500
1975	3590.0	0.4000	0.4000
1981	3560.0	0.4500	0.4500
1980	3550.0	0.5000	0.5000
1978	3430.0	0.5500	0.5500
1976	3420.0	0.6000	0.6000
1989	2780.0	0.6500	0.6500
1979	2620.0	0.7000	0.7000
1985	2580.0	0.7500	0.7500
1973	2460.0	0.8000	0.8000
1968	2450.0	0.8500	0.8500
1986	2230.0	0.9000	0.9000
1977	778.0	0.9500	0.9500

PGM J407 VER 3.7
(REV 11/5/81)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.

RUN-DATE 11/15/91 AT 1221 SEQ 1.0001

STATION - 13310700 /USGS S FK SALMON RIVER NR KRASSEL RANGER STATION ID 1967-1989 13310700 /USGS


31600.0
10000.0
3160.0
1000.0
316.0
100.0
***** NOTICE ***** NOTICE *****
* PRELIMINARY MACHINE COMPUTATION. *
* USER IS RESPONSIBLE FOR ASSESS- *
* MENT AND INTERPRETATION. *
PLOT SYMBOL KEY
* WRC FINAL FREQUENCY CURVE
O OBSERVED (SYSTEMATIC) PEAKS
$ HISTORICALLY ADJUSTED PEAKS
# SYSTEMATIC-RECORD FREQ CURVE
WHEN POINTS COINCIDE, ONLY THE
TOPMOST SYMBOL SHOWS.
ANNUAL PEAK MAGNITUDES / LOG SCALE /
99.5 99.0 95.0 90.0 80.0 70.0 50.0 30.0 20.0 10.0 5.0 2.0 1.0 0.5 0.2
ANNUAL EXCEEDANCE PROBABILITY, PERCENT (NORMAL SCALE)